INSTRUCTION MANUAL

MODEL 164
30 MHz
SWEEP GENERATOR

WAVETEK

9045 BALBOA AVENUE, SAN DIEGO, CALIFORNIA

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30 MHz
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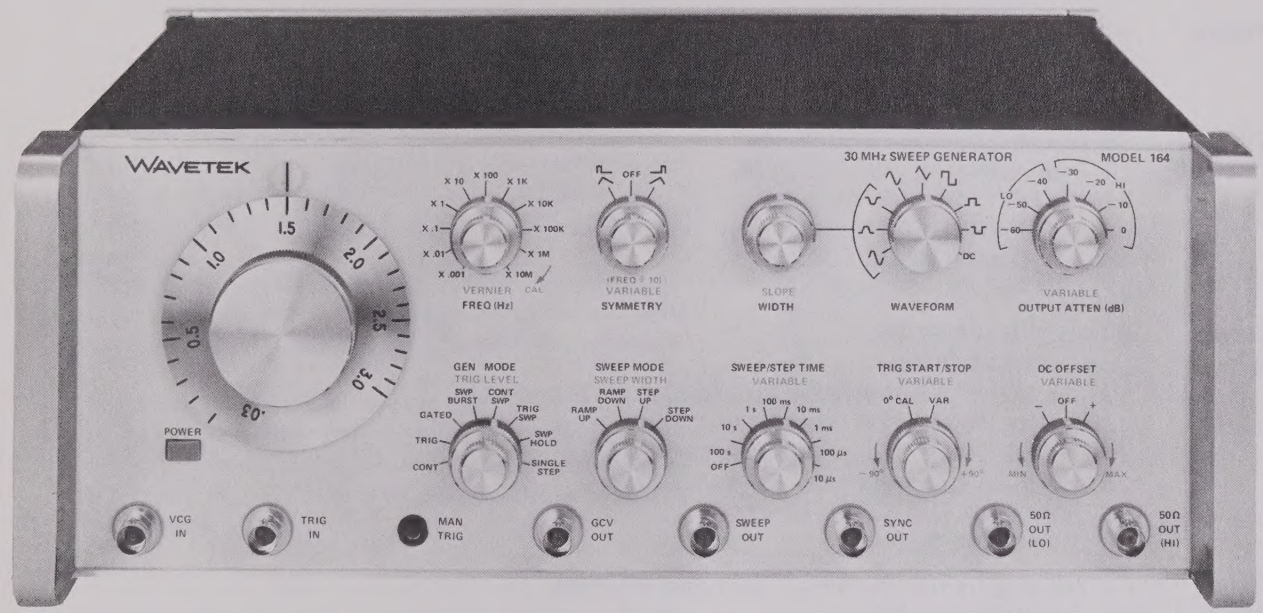

Figure i — Model 164 30 MHz Sweep Generator

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SECTION 1
INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The Model 164 Sweep Generator offers an extended waveform versatility plus a frequency range that spans twelve decades, from 30 μHz (9.2 hours per cycle) to 30 MHz.

The waveforms available are sine, square, triangle, trapezoidal and positive and negative rectangular and trapezoidal pulse, each with variable amplitude, dc offset and symmetry.

The trapezoidal waveform rise and fall times may be varied by means of independent slope, width and symmetry controls. Different rise times and fall times, both controllable, may be selected to suit your testing or triggering requirements.

The Model 164 employs a main generator, which can be triggered, gated or swept by an external signal. In addition, it has a ramp/step generator. The latter is used to sweep, sweep burst or step the frequency of the main generator. Frequency sweeping and stepping may be up or down. Steps may be automatically sequenced or triggered.

1.2 SPECIFICATIONS

1.2.1 Waveforms

Eight selectable waveforms, sine ∿ , triangle △ , square ⊓ , positive pulse ⎍ , negative pulse ⎏ , trapezoid ⏢ , positive trapezoid ⎍ , and negative trapezoid ⏢ , plus variable DC output. Symmetry of all waveform outputs is continuously adjustable from 1:19 to 19:1. Varying symmetry provides variable duty-cycle pulses, sawtooth or unsymmetrical trapezoidal waveforms. Separate sync output included.

Sweep generator ramp ⟋ and steps ⟋ for continuous or discrete-step sweep; up or down sweeping. The swept signal may be triggered, gated, single stepped or swept-and-held. Main generator frequency may be swept as much as 1000:1.

1.2.2 Operating Frequency Range

Frequency selectable from 0.00003 Hz to 30 MHz in the following ranges.

X 0.001	0.00003 Hz to 0.003 Hz
X 0.01	0.0003 Hz to 0.03 Hz
X 0.1	0.003 Hz to 0.3 Hz
X 1	0.03 Hz to 3 Hz
X 10	0.3 Hz to 30 Hz
X 100	0.3 Hz to 300 Hz
X 1K	3 Hz to 3 kHz
X 10K	30 Hz to 30 kHz
X 100K	300 Hz to 300 kHz
X 1 MHz	3 kHz to 3 MHz
X 10 MHz	30 kHz to 30 MHz

NOTE

When SYMMETRY control is used, indicated frequency is divided by a factor of approximately 10.

1.2.3 Sweep/Step Range

Sweep/step time is selectable from 10 μs to 100 s in the following ranges:

100 s to 10 s	0.01 Hz to 0.1 Hz
10 s to 1 s	0.1 Hz to 1 Hz
1 s to 100 ms	1 Hz to 10 Hz
100 ms to 10 ms	10 Hz to 100 Hz
10 ms to 1 ms	100 Hz to 1 kHz
1 ms to 100 μs	1 kHz to 10 kHz
100 μs to 10 μs	10 kHz to 100 kHz

1.2.4 Outputs

Main Output

Maximum output of sine, triangle, square and trapezoidal waveforms is 20 V p-p into open circuit and 10 V p-p into 50Ω load. Positive and negative trapezoids and pulses are 10 V peak into open circuit and 5 V peak into 50Ω. DC voltage is adjustable between ±10 volts, 50Ω source impedance. Output peak current is 130 mA minimum for all waveforms and DC. Precision output allows from 0 dB to −60 dB attenuation in 10 dB steps with a 20 dB vernier; maximum overall attenuation is −80 dB. High level 0 to

−50 dB and low level −40 to −80 dB outputs give optimum performance.

Sync Output
Approximately 0 to +4 V into open circuit, 50Ω source impedance. Rise and fall times are typically 10 ns into 50Ω load. Sync is a square waveform during symmetrical outputs, rectangular waveform when SYMMETRY control is ON.

Sweep Output
SWEEP OUT connector provides a 0 to +5 V positive ramp from a 600Ω impedance source when SWEEP MODE is RAMP UP or RAMP DOWN, or 0 to +5 V stair step waveform in 10 equal steps when SWEEP MODE is STEP UP or STEP DOWN.

GCV Output
GCV OUT connector provides voltage proportional to main generator frequency from a 600Ω impedance source.

1.2.5 DC Offset

Front panel controlled between ±10 Vdc into open circuit, ±5 Vdc into 50Ω load. Peak voltage output (signal peak plus dc offset) is limited to ±10 V into open circuit, ±5 V into 50Ω load. DC offset and output waveform are attenuated proportionately by the attenuator.

1.2.6 Sweep Modes

Ramp Up
Main generator sweeps linearly from frequency set on front panel to a higher frequency determined by SWEEP WIDTH control at a rate set by SWEEP/STEP TIME control, then returns immediately to start frequency.

Ramp Down
Same as RAMP UP except frequency decreases.

Step Up
Same as RAMP UP except main generator frequency steps up in 10 equal steps.

Step Down
Same as RAMP UP except main generator frequency steps down in 10 equal steps.

1.2.7 Main Generator Operational Modes

Continuous
Operating as a standard VCG (voltage controlled generator), frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

Triggered
Only one complete cycle of output appears at 50Ω OUT connector for each pulse applied to TRIG IN connector (or press of MAN TRIG switch).

Gated
Same as triggered mode except that output oscillations continue for duration of gating signal applied to TRIG IN connector.

Continuous Sweep
Main generator is repeatedly swept in one of the four sweep modes with start and stop frequencies set by the front panel controls.

Triggered Sweep
Main generator oscillates at the frequency set on the front panel. When triggered, it makes one sweep in the selected sweep mode and then returns to the start frequency.

Sweep Hold
Same as triggered sweep except output frequency can be held at final sweep frequency after sweep.

Sweep Burst
Main generator output is a gated swept frequency for the duration of the gate. Between gate signals, output is a dc level.

Single Step
Main generator steps to next one of eleven frequency levels when triggered; eleventh trigger returns output to start frequency.

1.2.8 Voltage Controlled Generator

VCG Control Range
Up to 1000:1 frequency change with external voltage input. Upper frequency is limited to maximum of selected range. Required external signal for full voltage control is 0 to 5 V with input impedance of 5 kΩ.

VCG Slew Rate
2% of range per μs.

VCG Linearity
0.0003 Hz to 3 MHz . . . . . ±0.5% of range

1.2.9 Triggered Generator

Trigger Input
Trigger pulse is 1 V p-p to ±50 V; input impedance is 10 kΩ, 33 pF; minimum pulse width is 25 ns; maximum repetition rate is 20 MHz.

Start/Stop Point Adjustment
Triggered-signal start/stop point is adjustable:
To 3 MHz . . . . . Approximately −90° to +90°
3 MHz to 30 MHz . . . . Approximately −90° to 0°

1.2.10 Horizontal Precision

Dial Accuracy for Symmetrical Waveforms*
0.0003 Hz to 300 kHz . ±(1% of setting +1% of full scale)
300 kHz to 30 MHz . . ±(3% of setting +2% of full scale)

Frequency Vernier
Electronic frequency vernier precision frequency adjustment is approximately 1% of range.

Time Symmetry*
0.0003 Hz to 30 Hz . . . . . ±1.0%
30 Hz to 300 kHz . . . . . ±0.5%

1.2.11 Vertical Precision

Amplitude Change with Frequency (Sine)
Less than:
0.1 dB to 300 kHz
0.2 dB to 3 MHz
2.5 dB to 30 MHz

Step Attenuator Accuracy
±0.25 dB per 10 dB step.

Stability*
Short term . . . . . ±0.05% for 10 minutes
Long term . . . . . ±0.25% for 24 hours
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry
All symmetrical waveforms are symmetrical about ground within ±1% of amplitude range up to 3 MHz (e.g. within ±100 mV with output attenuator at 0 dB).

1.2.12 Purity*

Sine Wave Distortion
10 Hz to 100 kHz . . Less than 0.5% (typically 0.25%)
0.0003 Hz to 3 MHz . . . . . Less than 1.0%
3 MHz to 30 MHz . All harmonics at least 26 dB down

Triangle Linearity
0.0003 Hz to 300 kHz . . . . . Greater than 99%

Square Wave Rise and Fall Time
Less than 12 ns (typically 8 ns) when terminated into 50Ω load.

Square Wave Total Aberrations
Less than 5%.

Trapezoidal Rise and Fall Time
Ratio of period to rise or fall time is continuously variable from 2:1 (triangle) to greater than 100:1 and limited to 12 ns (maximum) rise and fall time.

1.2.13 Environmental

Temperature
All specifications listed are for 25°C ±5°C. For operation from 0°C to 55°C, specifications including horizontal precision, amplitude symmetry, and sine wave distortion are derated by a factor of 2.

1.2.14 Mechanical

Dimensions
14½ in./36.8 cm wide; 5¼ in./13.3 cm high; 13½ in./34.3 cm deep.

Weight
13 lb/5.9 kg net; 20 lb/9 kg shipping.

Power
90 to 110 V, 105 to 125 V, 180 to 220 V or 210 to 250 V; 50 to 400 Hz; less than 50 watts.

NOTE

Specifications apply from 10 to 100% of a selected frequency range.

*SYMMETRY control OFF.

SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to knobs, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit.

NOTE

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 105 - 125 Vac line supply and with a 1/2 amp line fuse.

Conversion for 90 to 110 V, 180 to 220 V or 210 to 250 V operation requires resetting two switches on the inside of the rear panel. To reset the switches, unscrew the four captive screws securing the rear panel, and remove the rear panel. Set the two switches and select the fuse for the ac line voltage according to the following table.

AC Line Voltage	Switch A	Switch B	Fuse (SB)
90 - 110	115	LO	½ amp
105 - 125	115	HI	½ amp
180 - 220	230	LO	¼ amp
210 - 250	230	HI	¼ amp

2.2.2 Signal Connections

Use 50Ω shielded cables equipped with female BNC connectors to distribute all signals when connecting this instrument to associated equipment.

The two main outputs, 50Ω OUT (LO) and 50Ω OUT (HI), should be terminated with 50Ω load when used for optimum performance.

2.3 OPERATING CONTROLS

The operating controls and electrical connections for the Model 164 are shown in Figure 2-1. The listing below discusses each control and its function.

1. **POWER Switch** — Power is on when this pushbutton switch is in, and off when extended.

2. **Frequency Index** — The scribe line indicates the frequency dial setting. The index is illuminated when the unit is on.

3. **Frequency Dial** — The main frequency control. The setting on this dial multiplied by the frequency range setting is the basic output frequency of the generator. (The FREQ (Hz) VERNIER, the SYMMETRY control and VCG IN also affect the generator frequency.)

4. **FREQ (Hz) Range** — This 11 position switch selects the generator frequency range, which, when multiplied by the frequency dial setting, determines the basic output frequency of the generator.

5. **FREQ (Hz) VERNIER Control** — This control allows precision control over the output frequency. A complete turn of this vernier is equivalent to approximately one half of the smallest division on the main frequency dial. When in the full clockwise position (CAL), the settings on the main dial will be accurate.

6. **SYMMETRY Control** — The large knob selects a right-hand or left-hand waveform time-symmetry. The small VARIABLE knob varies the waveform time-symmetry up to 19:1 or 1:19. When these controls are used, the frequency range is divided by approximately 10.

   The duty cycle of the square wave can be varied from to ; the slope of the triangle from to ; and the rise to fall time ratio of the trapezoid from to . See

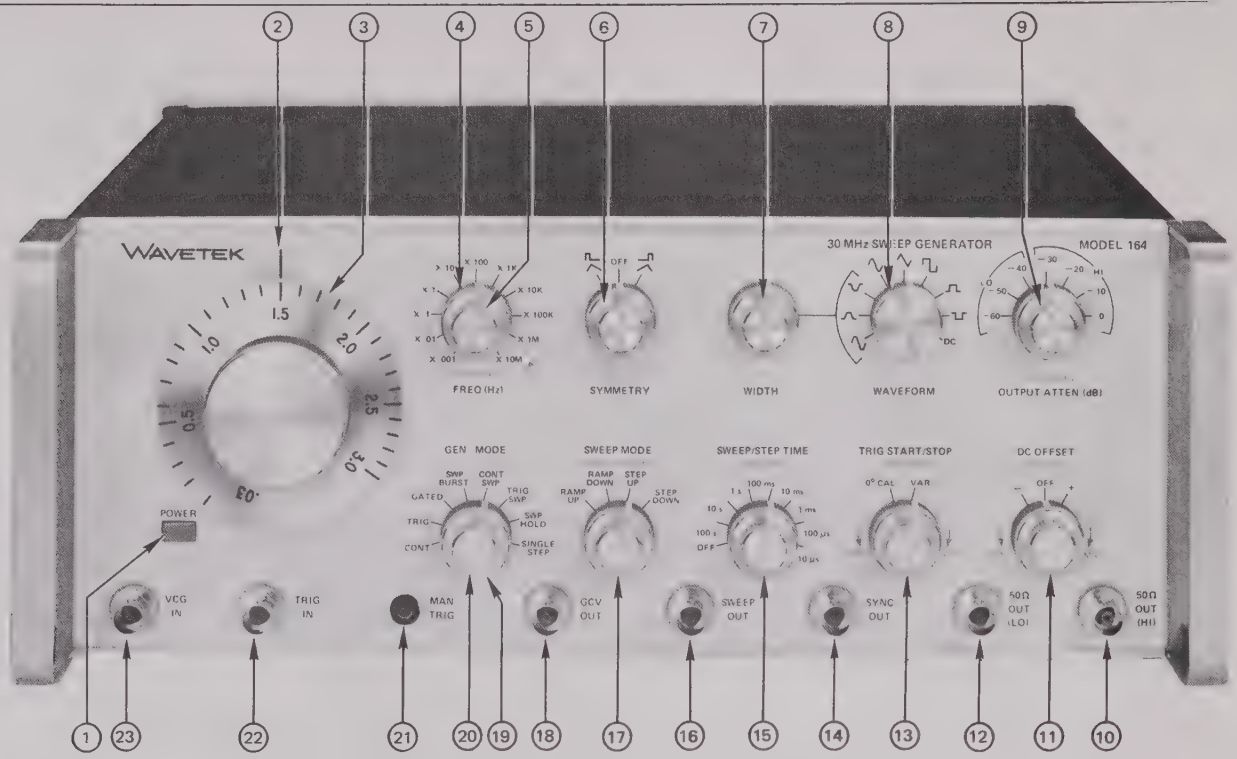


Figure 2-1. Operating Controls and Electrical Connections, Front Panel

Figure 2-2 for the sync signal relationship.

7. **SLOPE/WIDTH Control** — The small knob controls the slope of the trapezoidal waveforms. The large knob controls the time symmetry of the waveform. The setting of these controls does not affect the other waveforms. See Figure 2-2 for the sync signal relationship.

8. **WAVEFORM Selector** — This control selects the waveform that appears at the 50Ω output connector. The waveforms are sine ∿, triangle △, square ⊓, positive going rectangular pulse ⎍, negative going rectangular pulse ⎓, trapezoidal ⏢, positive going trapezoidal pulse ⏠, negative going trapezoidal pulse ⏡, and DC voltage.

9. **OUTPUT ATTEN (dB) Control** — The large knob attenuates the 50Ω output from 0 dB (10 V p-p max into 50Ω load) to −60 dB (10 mV p-p into 50Ω) in 10 dB steps. LO and HI indicate the correct output connector to use. The small VARIABLE knob may be used to continuously change the amplitude by approximately 20 dB. Maximum attenuation is −80 dB (1.0 mV p-p into 50Ω). The OUTPUT ATTEN (dB) VARIABLE control is inoperative when DC is selected on the WAVEFORM selector.

10. **50Ω OUT (HI)** — This is the selected waveform

NOTE: VARIABLE SYMMETRY OFF

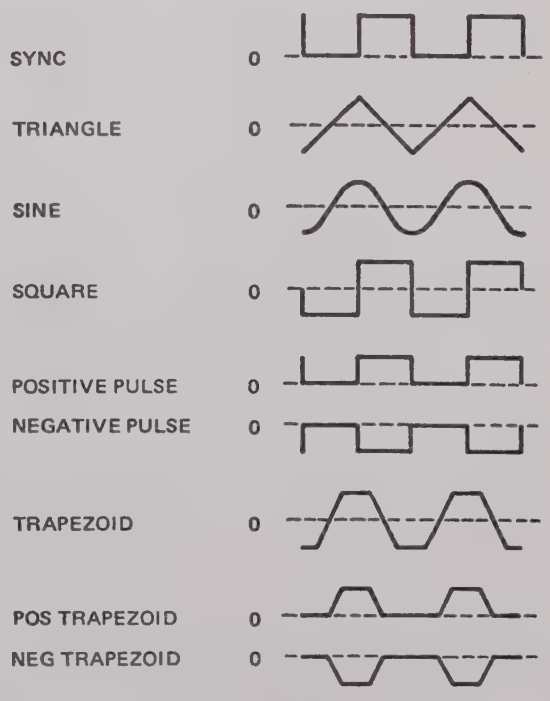


Figure 2-2. Selectable Waveforms and Sync Signal Phase and Polarity Relationships

output for the main generator or a dc voltage when the OUTPUT ATTEN (dB) switch is set 0 to −30 dB. The Model 164 operating into an open circuit provides 20 V p-p maximum, or into a 50Ω load provides a 10 V p-p output for the sine, triangle, square and trapezoidal waveforms; maximum trapezoidal and rectangular pulses are 10 V into an open circuit and 5 V into a 50Ω load.

11. **DC OFFSET Control** – Adjusts dc base line offset above (+) or below (−) signal ground; or, when DC is selected on the WAVEFORM selector, adjusts dc voltage at the 50Ω output. The large knob selects polarity, and the small VARIABLE knob adjusts voltage up to ±10 Vdc into an open circuit (±5 Vdc into 50Ω load).

    Peak signal output (waveform plus dc offset) is limited to ±10 Vdc into an open circuit (±5 Vdc into a 50Ω load). (The OUTPUT ATTEN (dB) control affects dc offset as well as waveform amplitude.)

12. **50Ω OUT (LO)** – This is the selected waveform output for the main generator or a dc voltage when the OUTPUT ATTEN (dB) control is set −40 dB to −60 dB.

13. **TRIG START/STOP Control** – The large knob switched to VAR allows the triggered output signal start and stop point to be varied by turning the small knob. For sine and triangle waveforms, the start/stop point may be varied from negative peak voltage to almost positive peak voltage. (At the higher frequencies, the limits are negative peak to waveform zero level.) The square wave always starts/stops at negative peak voltage. The rectangle pulses always start/stop at waveform zero level. The trapezoidal waveform start/stop points are continuously variable. When the large knob is set to 0° CAL, sine and triangle waveforms start/stop at waveform zero level; square and positive rectangular pulse waveforms start/stop at negative peak level; trapezoidal and trapezoidal pulse waveform start/stop points vary with the SLOPE/WIDTH control settings.

14. **SYNC OUT** – This is a square wave (or rectangular if SYMMETRY control is in use) with the same frequency and same polarity of the selectable square wave at a 50Ω output. Amplitude into an open circuit is greater than 4 V p-p (2 V p-p into 50Ω). See Figure 2-2.

15. **SWEEP/STEP TIME Control** – When operating in any of the sweep modes, this control determines the duration of the sweep or a single step by controlling the frequency of the sweep generator, which is independent of the frequency of the main generator. The large knob selects the range, which is bounded by the time values printed on the control panel on either side of the detent setting. The small VARIABLE knob varies the time throughout the range; rotating the VARIABLE knob ccw increases the sweep time at least by 10:1.

16. **SWEEP OUT** – This output provides a fixed 0 to nominal +5 V sawtooth or 10-step waveform, depending on the ramp or step sweep mode. The frequency of these waveforms is controlled by SWEEP/STEP TIME.

17. **SWEEP MODE/SWEEP WIDTH Control** – The large knob selects one of the step or ramp sweep signals. The small knob determines the amplitude of the sweep signal fed to the main generator, thereby determining the bandwidth of frequencies swept when in a sweep mode.

18. **GCV OUT** – This is Generator Control Voltage output, a voltage proportional to the generator output frequency.

19. **GEN MODE Switch** – Selects the operating mode of the main generator (50Ω OUT) as follows:

    a. CONT Mode – The generator operates continuously as a standard Voltage Controlled Generator (VCG). Frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

    b. TRIG Mode – The generator will give one complete cycle of output when the MAN TRIG is pressed or for each cycle of signal applied to TRIG IN. The generator output cycle begins and ends as determined by the TRIG START/STOP control. Since the internal sweep operates independently it can be used to provide a repetitive trigger signal by connecting the SWEEP OUT to TRIG IN.

    c. GATED Mode – Operates the same as TRIG mode except that the generator will continue to have output for the full time that the MAN TRIG switch is held down or the gate signal at TRIG IN exceeds the gating level set by the TRIG LEVEL control.

    d. SWP BURST Mode – When MAN TRIG is pressed or a pulse is applied to TRIG IN, both the main generator and sweep operator are triggered; the

main generator sweeps and holds if the gate is longer than the sweep generator period or sweeps once if the gate is shorter than the sweep period. The 50Ω OUT signal exists only for the duration of the gate. Sweep characteristics are determined by the sweep controls. See Figures 2-12 and 2-13 for signal characteristics in SWP BURST mode.

e. CONT SWP Mode — The main generator operates continuously and is repetitively swept. Sweep characteristics are determined by the sweep controls.

f. TRIG SWP Mode — The main generator oscillates at the start frequency until a trigger signal is applied. The frequency then sweeps to the frequency determined by the SWEEP WIDTH control and then returns to the start frequency until another trigger is applied.

g. SWP HOLD Mode — The main generator oscillates at the start frequency until a gate signal is applied to the TRIG IN connector. The main generator then sweeps from the start frequency to the frequency determined by the SWEEP WIDTH control and remains at that frequency for the duration of the gate signal. When the gate falls, the generator returns to the start frequency. If the gate is quicker than the sweep, this mode is identical to TRIG SWP mode.

h. SINGLE STEP Mode — This mode is to be used in conjunction with STEP UP (or DOWN) on the SWEEP MODE control. The main generator oscillates at a start frequency until triggered. When MAN TRIG is pressed or a signal is applied to TRIG IN, the frequency output steps to the first of 10 levels determined by the SWEEP WIDTH control. Each successive trigger steps the frequency to another level. On the eleventh trigger, the frequency returns to start frequency.

20. **TRIG LEVEL Control** — A continuously variable adjustment of the TRIG IN circuitry. When full ccw, approximately a positive going pulse of +7.5 V (A, Figure 2-3) or greater voltage is required for triggering. In the full cw position, a positive going pulse of approximately −7.5 V (B, Figure 2-3) or more positive voltage is required for triggering. In the GATED mode, the generator will begin to run continuously at some position of the control cw past 12 o'clock. When using the MAN TRIG, this control must be ccw of the midpoint.

21. **MAN TRIG Switch** — When in any of the trigger modes, pressing this switch furnishes the trigger. When in any of the gate modes, this switch furnishes the gate signal for the duration that it is pressed and held down. The TRIG LEVEL control must be ccw from midpoint for proper MAN TRIG operation.

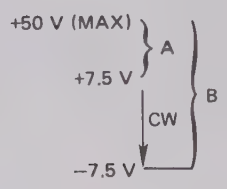


Figure 2-3. Range of Triggering Voltage

22. **TRIG IN** — A dc coupled input with 10 kΩ, 33 pF input impedance. The TRIG LEVEL control adjusts the sensitivity of the generator to this input signal. Trigger signals must be 1 V p-p or greater but within the range of ±50 V. Trigger signal width must be 25 ns or greater. Trigger frequency must be less than 20 MHz.

23. **VCG IN** — This connector allows external control of frequency. With 0 volt in, the basic generator frequency (50Ω OUT) is determined by the frequency range selected and the frequency dial setting. A positive VCG voltage will increase this frequency, and a negative voltage will decrease the frequency. Input impedance is 5 kΩ. Restrictions for linear operation are (1) the upper frequency limit is the value selected with the FREQ (Hz) switch, (2) the lower frequency limit is one-thousandth the value selected with the FREQ (Hz) switch. A 5-volt excursion covers the 1000: 1 frequency range.

2.4 INSTALLATION CHECKS

The following procedures are used to determine that the instrument is operating properly. Field calibration and checkout instructions (to be supplied) are to be used to ensure that the instrument complies with the specifications. If the instrument is not operating properly or within specifications, refer to the warranty on the back of the title page.

Use a Tektronix Model 454 oscilloscope (or equivalent) and a Counter-Timer when performing these installation checks.

1. After connecting the line cord to the ac line, set the front panel controls and switches as follows:

POWER	In
Frequency Dial	1.0
FREQ (Hz) Range	X 1K
FREQ (Hz) VERNIER	Fully Clockwise
SYMMETRY	OFF
WAVEFORM	⊓
OUTPUT ATTEN (dB)	0
OUTPUT ATTEN (dB) VARIABLE	Fully Clockwise
DC OFFSET	OFF
TRIG START/STOP	0° CAL
SWEEP/STEP TIME	OFF
GEN MODE	CONT

2. Connect the 50Ω OUT (HI) connector with a shielded cable terminated in a 50 ohm load to the oscilloscope and set FREQ (Hz) VERNIER to obtain 1 kHz display on the oscilloscope. Approximately 10 V p-p should be displayed.

3. Rotate OUTPUT ATTEN (dB) VARIABLE control full ccw. Increasing signal attenuation should be observed. Return to full cw.

4. Set SLOPE control (small knob) full cw and WIDTH control (large knob) at approximately midpoint.

5. Check amplitudes of sine ∿ , triangle △ and trapezoidal ⊓ waveforms. They should be approximately 10 V p-p.

6. Use SLOPE/WIDTH control to vary the slope and time symmetry of the trapezoidal waveform.

7. Check minimum and maximum amplitudes of positive and negative pulse waveforms, both rectangular and trapezoidal. Amplitudes should be approximately 5 volts above or below the 0 volt level.

8. Switch the FREQ (Hz) range control to check range-to-range tracking accuracy. The oscilloscope should show approximately the FREQ (Hz) range value.

9. Select the square waveform and rotate the SYMMETRY switch to ◿ and the VARIABLE control full cw. Waveform asymmetry should be approximately 19:1. Rotate the VARIABLE control full ccw; the waveform should be symmetrical. Verify that the other switch position and VARIABLE control give approximately 1:19 waveform asymmetry.

10. Turn the SYMMETRY switch to OFF and select DC on the WAVEFORM selector. Use a shielded cable with BNC connectors to connect SYNC OUT to the oscilloscope trigger input.

11. Set the DC OFFSET switch to + and rotate the VARIABLE control full cw. The amplitude should be approximately +5 V into a 50Ω load.

12. Set the DC OFFSET switch to –. Amplitude should be approximately –5 V.

13. Rotate the OUTPUT ATTEN (dB) switch thru each position. Verify the attenuation on the oscilloscope. (The VARIABLE control is inoperative for DC.) Repeat using 50Ω OUT (LO) connector.

14. Turn the DC OFFSET switch to OFF and connect the SWEEP OUT to the oscilloscope without a load. Set SWEEP MODE switch to RAMP UP. With the SWEEP/STEP TIME switch set to 10 ms I 1 ms and the VARIABLE control set full cw (1 ms sweep), verify that the SWEEP OUT waveform is approximately a 1 kHz sawtooth. (RAMP DOWN position gives the same positive going sawtooth waveform.)

NOTE

The SWEEP/STEP TIME VARIABLE control is not calibrated.

15. Set the VARIABLE control full ccw. The SWEEP OUT waveform should be approximately 100 Hz.

16. Check the SWEEP OUT frequency in all positions of the SWEEP TIME switch and at both the cw and ccw ends of the VARIABLE control.

17. Change SWEEP MODE switch to observe stair steps up. (Both STEP UP and STEP DOWN give the same positive going waveform.) Notice that the SWEEP/STEP TIME setting is the duration of each step.

18. Set the WAVEFORM selector to ∿ , the SWEEP MODE switch to STEP UP, the SWEEP/STEP TIME switch to 10 s I 1 s, and the VARIABLE control to full cw (1 s sweep). Use a shielded cable equipped with BNC connectors and connect SWEEP OUT to VCG IN. Connect the oscilloscope to 50Ω OUT (HI) and observe the stepping of the output frequency.

19. Remove the cable from VCG IN and connect TRIG IN to SWEEP OUT. Set SWEEP MODE to RAMP UP. Set the GEN MODE switch to TRIG and the SWEEP/STEP TIME switch to 100 ms I 10 ms. Rotate the

TRIG LEVEL near 12 o'clock. The oscilloscope should display one cycle of the waveform each time the sweep output triggers the main generator.

20. Set the GEN MODE switch to GATED and rotate the TRIG LEVEL control while observing the oscilloscope. The multiple cycles of the selected output waveform should appear when the TRIG LEVEL control is rotated cw and reduce to one cycle, then none, when the control is turned ccw. At some point ccw the generator stops oscillating, and at some point cw it goes into continuous operation.

21. Turn SWEEP/STEP TIME switch to OFF. Use MAN TRIG switch to gate waveforms. Waveforms should be continuous when MAN TRIG switch is held down.

22. Set the GEN MODE switch to TRIG. Use MAN TRIG switch to trigger waveforms. One cycle should appear each time the trigger is pressed.

23. Turn SWEEP/STEP TIME switch to 10 ms ▮ 1 ms and GEN MODE switch to GATED. Set TRIG START/STOP switch to VAR and rotate VARIABLE knob full cw. Observe the start/stop point of the waveform. Rotate the VARIABLE knob and trigger waveforms to observe the varying start/stop points. At full cw the waveform should start/stop at approximately +90° (positive peak); at full ccw, approximately −90° (negative peak); and at midpoint, 0°. (TRIG LEVEL may require adjusting.) Set TRIG START/STOP switch to 0° CAL. Disconnect the cable to TRIG IN.

NOTE

Steps 24 and 25 set low and high frequencies of the sweep range.

24. Set the GEN MODE switch to SWP HOLD, TRIG LEVEL control to 9 o'clock, FREQ (Hz) range to X 10K, SWEEP/STEP TIME switch to 10 s ▮ 1 s and SWEEP MODE switch to RAMP UP. With a counter, the frequency dial and FREQ (Hz) VERNIER control, set the frequency to 30 Hz.

25. Rotate the TRIG LEVEL control to 3 o'clock (triggering the generator) and rotate the SWEEP WIDTH control to set the frequency to 30 kHz.

26. Rotate the TRIG LEVEL control to 9 o'clock, and the GEN MODE switch to CONT SWP. Output should be the 30 to 30 kHz swept signal continuously repeating.

27. Set GEN MODE switch to TRIG SWP and press the MAN TRIG switch. The generator output should be the swept signal occurring once for each trigger.

28. Set the GEN MODE switch to SINGLE STEP and SWEEP MODE switch to STEP UP. Press the MAN TRIG ten times while observing the stepped increase in output frequency. The eleventh trigger should return the frequency to 30 Hz.

29. Remove the cable from 50Ω OUT and connect to GCV OUT. Connect SYNC OUT to the oscilloscope trigger input. Trigger the generator as in the previous step. Observe the varying voltage corresponding to the varying frequency output. Reconnect the cable to 50Ω OUT (HI).

30. Set the GEN MODE switch to SWP BURST and press the MAN TRIG switch and hold. A frequency stepping and hold should occur. When the switch is released, no signal should be present.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial installation checks given in Paragraph 2.4 of this manual. It is recommended that a one-half hour warm-up period be allowed for the associated equipment to reach a stabilized operating temperature, and for the Model 164 to attain stated accuracies.

There are almost unlimited ways to set up the generator and waveforms that may be obtained. The following sections describe basic configurations and how to set them up.

2.5.1 Operation as a Function Generator

1. Depress the POWER switch. Properly terminate the 50Ω OUT (HI) connector.

2. Set the GEN MODE switch to CONT.

3. Set the FREQ (Hz) range switch to the desired multiplier.

4. Set the frequency dial to the desired setting. Use the frequency VERNIER for precision frequency setting if necessary.

5. Select desired basic output waveform using the WAVEFORM selector.

6. Set OUTPUT ATTEN (dB) switch for desired output

level and amplitude. If a LO amplitude signal is selected, use the 50Ω OUT (LO) connector.

For reference, the following table gives the approximate output amplitude levels at attenuator settings. The output levels of the positive and negative pulse waveforms are one-half of these levels.

TABLE 2-1

Attenuator Position	Peak-to-Peak Output into 50Ω Load	
	Maximum (variable full cw)	Minimum (variable full ccw)
0 dB	10 V	1 V
−10 dB	3.2 V	320 mV
−20 dB	1 V	100 mV
−30 dB	320 mV	32 mV
−40 dB	100 mV	10 mV
−50 dB	32 mV	3.2 mV
−60 dB	10 mV	1 mV

7. Set the SYMMETRY control for desired asymmetry. The SYMMETRY control is used to develop ramp waveforms from the triangle, to vary the duty cycle of the square wave, to vary the ratio of rise/fall time of the trapezoidal waveform. Figure 2-4 shows the effect of this control on output waveforms. The output frequency is divided by approximately a factor of 10 when an asymmetrical waveform is selected.

8. When the trapezoidal waveform is selected, the WIDTH control is used to vary the duty cycle of the waveform and the SLOPE control is used to vary both rise and fall times. See Figure 2-5. Use the SYMMETRY control if asymmetrical rise and fall times are desired. See Figure 2-4.

9. Select the desired polarity of dc offset and the amount of offset using the DC OFFSET control. Offset voltage plus peak voltage cannot exceed the voltage range limit, ±5 volts in the 0 dB range. If an excessive amount of dc offset is used, waveform clipping may be observed (see Figure 2-6). Both signal and offset are attenuated by the attenuator.

2.5.2 Operation as a Voltage Controlled Generator

The VCG input connector can be used to externally control the frequency of the generator. If a positive voltage is applied to the VCG input terminal, the frequency will increase from the setting of the frequency controls. A negative voltage will cause the frequency to decrease from the setting of the frequency controls.

A 5 V excursion in VCG voltage can vary the frequency up to 1000:1 in each range as follows:

Range	Limits for Linear Operation	
	Lower	Upper
X0.001	0.003 mHz	0.003 Hz
X0.01	0.03 mHz	0.03 Hz
X0.1	0.3 mHz	0.3 Hz
X1	3 mHz	3 Hz
X10	30 mHz	30 Hz
X100	300 mHz	300 Hz
X1K	3 Hz	3 kHz
X10K	30 Hz	30 kHz
X100K	300 Hz	300 kHz
X1M	3 kHz	3 MHz
X10M	30 kHz	30 MHz

The upper limit may be exceeded as there is an overranging capability; however, overranging will be nonlinear and the operation is unspecified. Operation below the lower limit of any range setting is not recommended.

The nomograph of Figure 2-7 shows the characteristics of the VCG circuit. Column A gives the frequency dial setting, column B, the VCG voltage and column C, a factor representing the resultant frequency of the generator.

In example 1, the dial is set at 1.5 and no VCG input is applied. Extend a straight line from 1.5 (dial setting) thru 0 volt (VCG voltage). The result is an output frequency factor of 1.5. Multiply 1.5 by the range multiplier for actual 50Ω OUT frequency.

In order to set the generator at 0.003 X the range multiplier (1/1000 of the range), the following procedure is to be followed (Example 2):

1. Using the frequency dial and a counter or oscilloscope, set the generator frequency to 0.03 X the range multiplier.

2. By rotating the VERNIER ccw, decrease the frequency to 0.003 X the range multiplier.

As can be seen from the nomograph a +5 volt VCG input will then cause the frequency to increase to the maximum of 3 X the range (an increase from 0.003 X to 3 X is 1:1000).

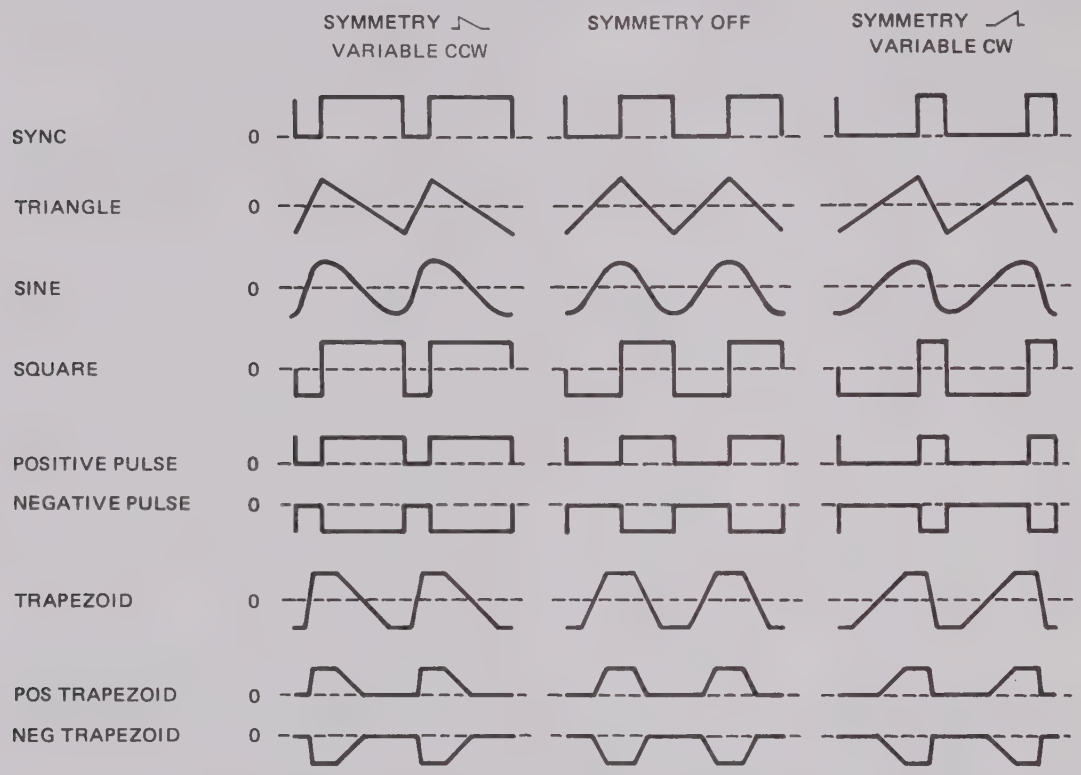


Figure 2-4. Effect of Symmetry Adjustment on Waveforms

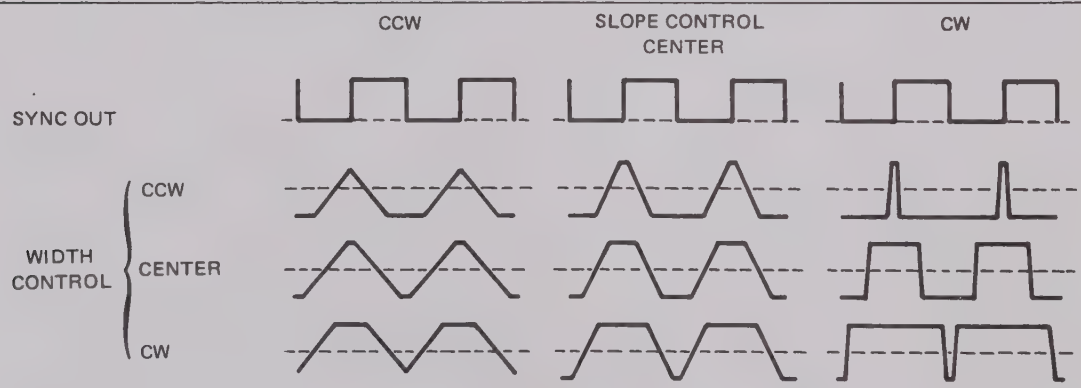


Figure 2-5. Effect of SLOPE/WIDTH Control on the Trapezoid Waveform

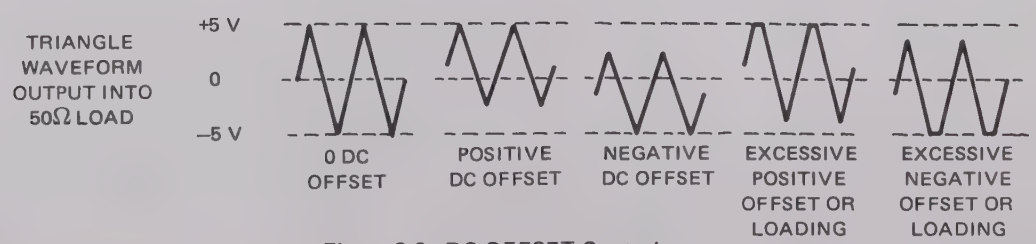


Figure 2-6. DC OFFSET Control

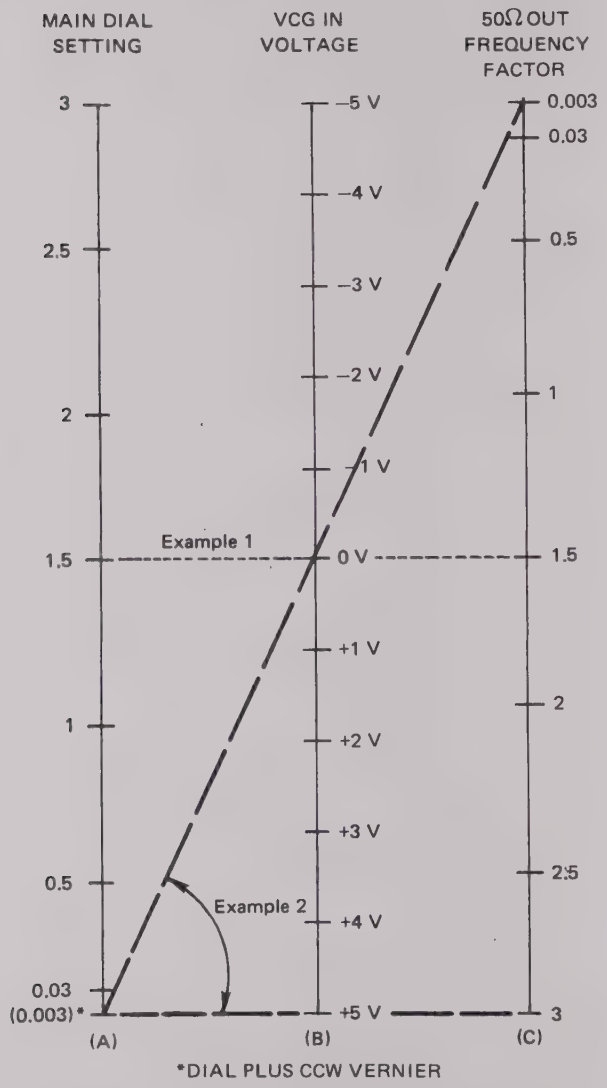


Figure 2-7. VCG Voltage-to-Frequency Nomograph

2.5.3 Operation as a Triggered Generator

1. Adjust the generator as for continuous operation (Paragraph 2.5.1); then set the GEN MODE switch to TRIG.

2. For external triggering, apply a repetitive signal, any waveform from 1 V p-p to less than ±50 V peak voltage (see TRIG IN specification, Paragraph 2.3, Item 22), to TRIG IN connector. Set the TRIG LEVEL control for proper triggering. See Figure 2-8 for the timing relationship of the trigger input, sync output and selected waveform output.

3. If manual triggering is desired, set the TRIG LEVEL control full ccw and operate the MAN TRIG switch for each cycle of selected output waveform.

NOTE

The SWEEP OUT connector may be used as a repetitive trigger source. In this case, the SWEEP/STEP TIME control determines the repetition rate of the triggered output signal.

2.5.4 Gated or Tone Burst Operation

With the generator adjusted as in trigger operation, change the GEN MODE control to GATED position. The generator output will then be a burst of cycles. If the trigger is the SWEEP OUT sawtooth waveform, the duration of the burst is adjustable by the TRIG LEVEL control (see Figure 2-8). Notice that the last cycle gated is completed at time t5, if the gate signal is removed between time t3 and t4. In manual gating, set TRIG LEVEL control full ccw. The tone burst continues as long as the manual switch is pressed.

The generator can be made to free run in this mode at certain settings of the trigger level control. By resetting the trigger level control, normal gated operation can be re-established.

2.5.5 Operation as a Sweep Generator

The second internal generator, the sweep generator, can modulate the main generator frequency in sweep or step fashion. The four modes, ramp up, ramp down, step up and step down, can be used in conjunction with the main generator modes as described in the next paragraphs.

2.5.5.1 SWEEP OUTPUT AND GENERATOR CONTROL VOLTAGE (GCV) OUTPUT

A fixed amplitude, 0 to >5 V, 600Ω impedance, ramp or staircase is provided at the SWEEP OUT connector. A voltage output, 0 to > 5 V, 600Ω impedance, which is directly proportional to the main generator frequency is provided at the GCV OUT connector.

2.5.5.2 SETTING THE SWEEP FREQUENCY LIMITS

1. Set the SWEEP/STEP TIME switch to 100 ms or faster by monitoring SWEEP OUT.

2. Select the desired SWEEP MODE switch setting.

3. Set the GEN MODE switch to SWP HOLD.

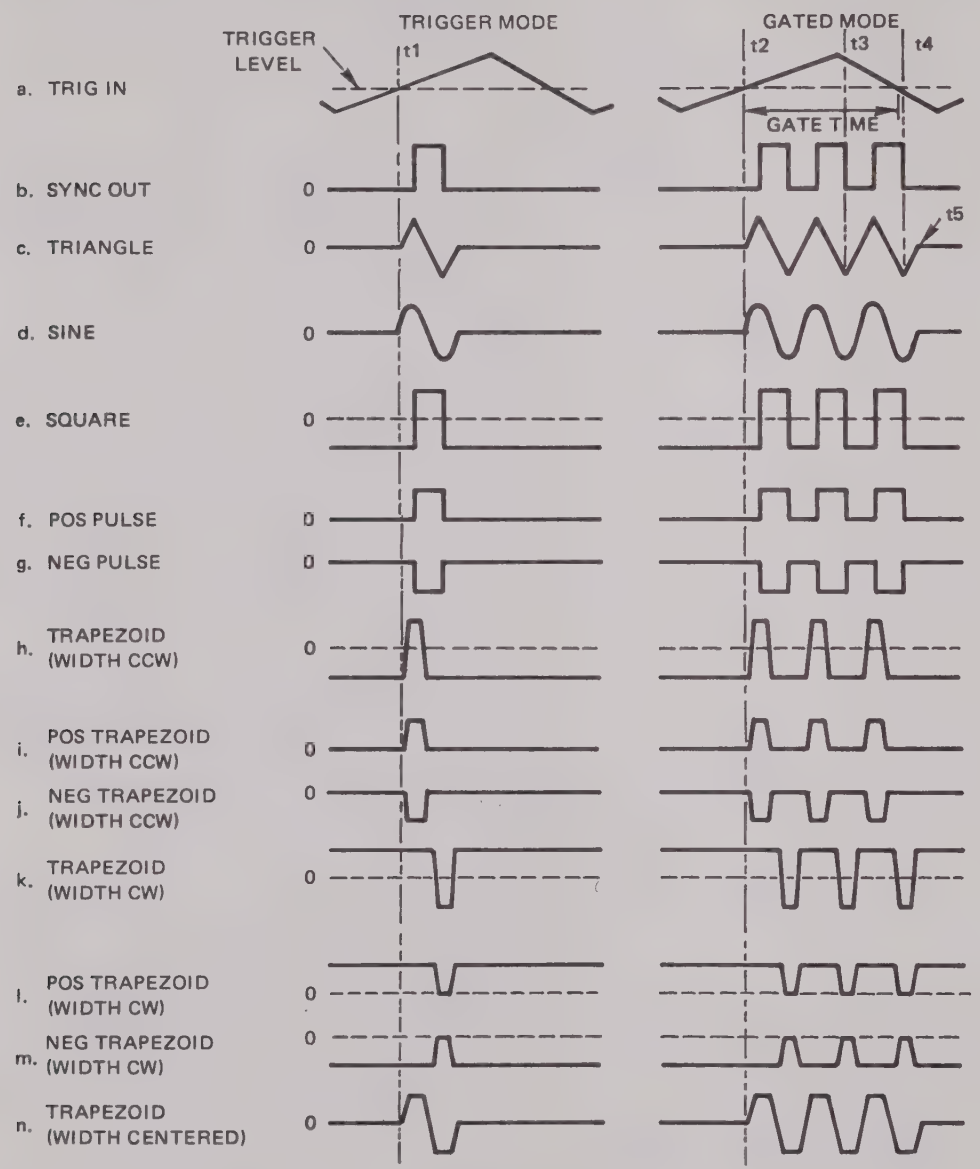


Figure 2-8. Trigger and Gated Operations

4. Set the TRIG LEVEL control full ccw.

5. Select the desired frequency range, using the FREQ (Hz) selector.

6. Set the desired sweep start frequency, using the frequency dial and VERNIER and monitoring the frequency at 50Ω OUT with an oscilloscope or counter.

7. Hold the MAN TRIG switch down; set the desired stop sweep frequency, using the SWEEP WIDTH control.

NOTE

Be sure this frequency does not exceed the range frequency limit; see Operating Frequency Range, Paragraph 1.2.2.

8. Sweep frequency limits are now set. Select the desired main generator mode using the GEN MODE switch. Notice that the generator frequency will sweep or step between the two limits when CONT SWP, TRIG SWP, SWP HOLD or SINGLE STEP is selected.

9. Select the desired SWEEP/STEP TIME.

2.5.6 Operation as a Continuous Sweep Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to CONT SWP.

3. The proper waveform outputs at SWEEP OUT and GCV OUT are shown in Figure 2-9.

2.5.7 Operation as a Trigger Sweep Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to TRIG SWP.

3. Connect a repetitive signal (see Trigger Input specification, Paragraph 1.2.9) to TRIG IN connector.

4. Adjust the TRIG LEVEL control for proper triggering.

5. The main generator will sweep from the start frequency to the stop frequency and reset back to start frequency for every cycle of the TRIG IN signal. However, if the trigger rate is faster than the sweep rate, the sweep generator will neglect all trigger signals during each cycle of sweep. See Figure 2-10.

6. Set the TRIG LEVEL control to full ccw if manual triggering is desired and operate the MAN TRIG switch for each cycle of sweep.

2.5.8 Operation as a Sweep and Hold Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to SWP HOLD.

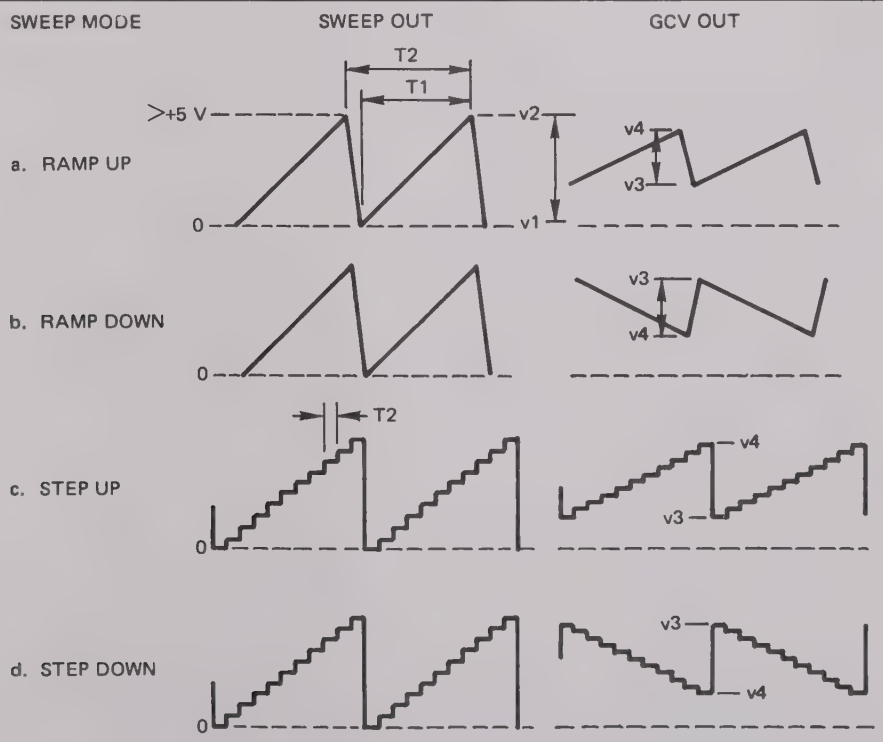
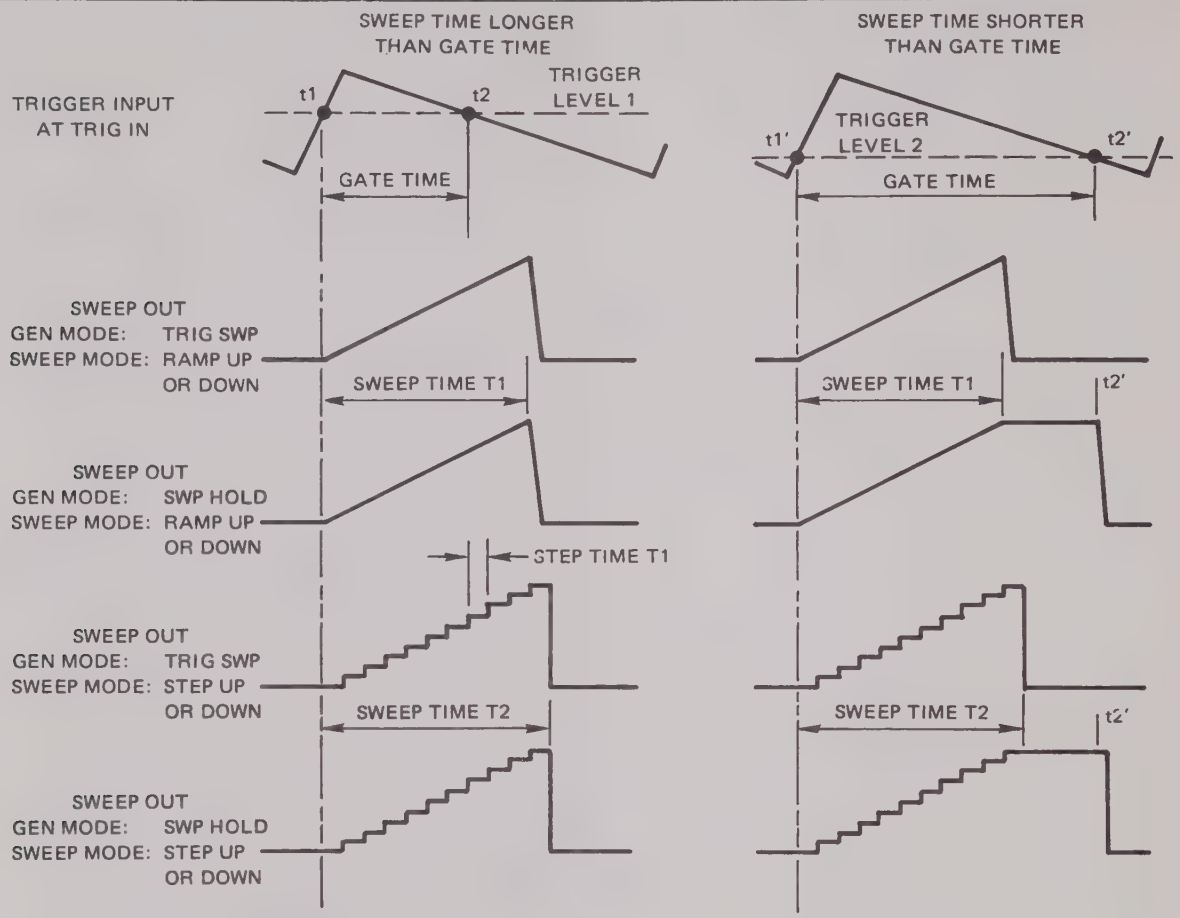


Figure 2-9. SWEEP OUT and GCV OUT at the Continuous Sweep Mode



NOTES

1. *T1 is the sweep time determined by the SWEEP/STEP TIME control setting when RAMP UP or RAMP DOWN is selected.*

2. *T2 is the time duration for each step and is also determined by the SWEEP/STEP TIME control setting when STEP UP or STEP DOWN is selected.*

3. *Voltage V3 is proportional to the sweep start frequency which is set by the frequency dial and VERNIER.*

4. *Voltage V4 is proportional to the sweep stop frequency. The voltage between V3 and V4 is proportional to the frequency range and is determined by the SWEEP WIDTH control setting.*

5. *Notice that the SWEEP OUT is always started from 0 volt to >+ 5 volts even if RAMP DOWN or STEP DOWN is selected. This is for the convenience of using it as the horizontal input signal of an oscilloscope or X-Y recorder.*

NOTE

The first step of staircase occurs after one "step time" delay from the start of gating signal, t1 and t1'. In the SWP HOLD mode, the staircase does not necessarily reset at time t2' when the gating signal is terminated, but at the time when first multiple "gate time" occurs after t2'.

Figure 2-10. Sweep Output for Triggered Sweep and Sweep-and-Hold Modes

3. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN.

4. Adjust the TRIG LEVEL control for proper triggering.

5. The generator frequency will hold at its sweep stop frequency only if the gating time is longer than the sweep time. See Figure 2-10. Also the sweep generator will neglect all trigger input signals during a sweep cycle.

6. For manual triggering, set the TRIG LEVEL control full ccw and operate the MAN TRIG switch for each cycle of sweep.

2.5.9 Operation as a Single Step Generator

1. Select the desired STEP UP or STEP DOWN mode on the SWEEP MODE switch and set up the frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to SINGLE STEP.

3. For maximum stepping rate (100 kHz), the SWEEP/STEP TIME control should be set at 100 μs I 10 μs with the VARIABLE full cw.

4. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN connector.

5. Adjust the TRIG LEVEL control until the SWEEP OUT signal advances one step for every cycle of trigger input signal. See Figure 2-11.

6. If manual triggering is desired, set TRIG LEVEL to full ccw and operate MAN TRIG switch for each step.

2.5.10 Operation as a Sweep Burst Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep limit as in Paragraph 2.5.5.2, except that the stop frequency should be set to approximately 10% beyond the desired stop frequency.

2. Set the GEN MODE switch to SWP BURST.

3. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN as a gating signal. See Paragraph 2.5.4.

4. Adjust the TRIG LEVEL control for proper triggering.

5. For best results, the sweep limit should be set to longer than the duration of the burst to avoid the last-cycle transient due to the reset of the sweep signal. See Figure 2-12.

6. If the trigger rate is faster than the sweep rate, several sweep tone bursts can be generated during each sweep. If the trigger signal becomes a narrow pulse, an interesting signal can be generated as shown in Figure 2-13.

2.5.11 Synchronized Sweep Operation

Not only can the sweep generator be used to trigger the main generator, as in the case of TRIG or GATED mode of operation, but the main generator can also be used to trigger the sweep generator. The GEN MODE switch is set at TRIG SWP and triggered by the main generator (SYNC OUT connected to TRIG IN). The result is a continuous frequency sweeping signal but the sweep start is synchronized

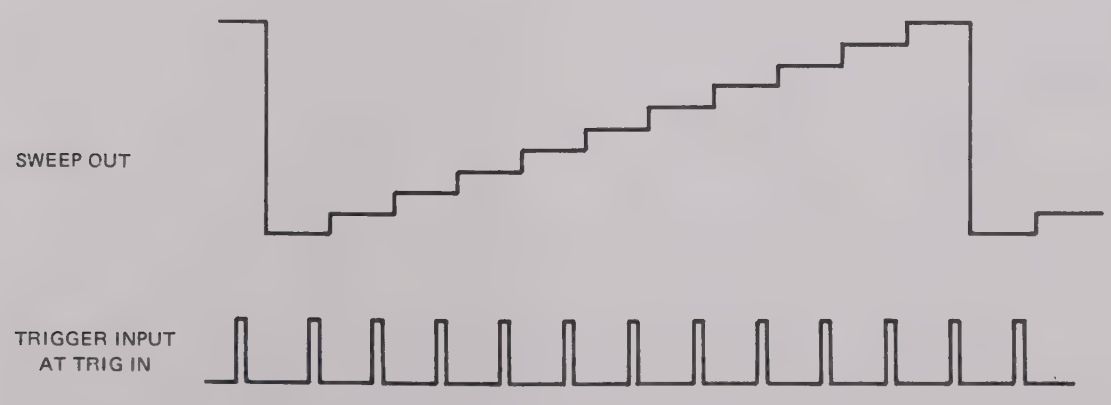


Figure 2-11. Single Step Mode Operation

to the main generator. Therefore, a stationary waveform display in oscilloscope is possible.

1. Set up the generator as in TRIG SWP mode. See Paragraph 2.5.7.
2. Connect SYNC OUT to TRIG IN with a coaxial cable.
3. Connect SWEEP OUT to the external trigger input of an oscilloscope and set the oscilloscope trigger to external and to negative trigger.
4. Adjust the TRIG LEVEL control of the generator until the output frequency is sweeping.
5. It may be necessary to adjust the generator SWEEP/STEP TIME slightly to obtain a stable display. For best results keep the ratio of main generator frequency less than 40:1.

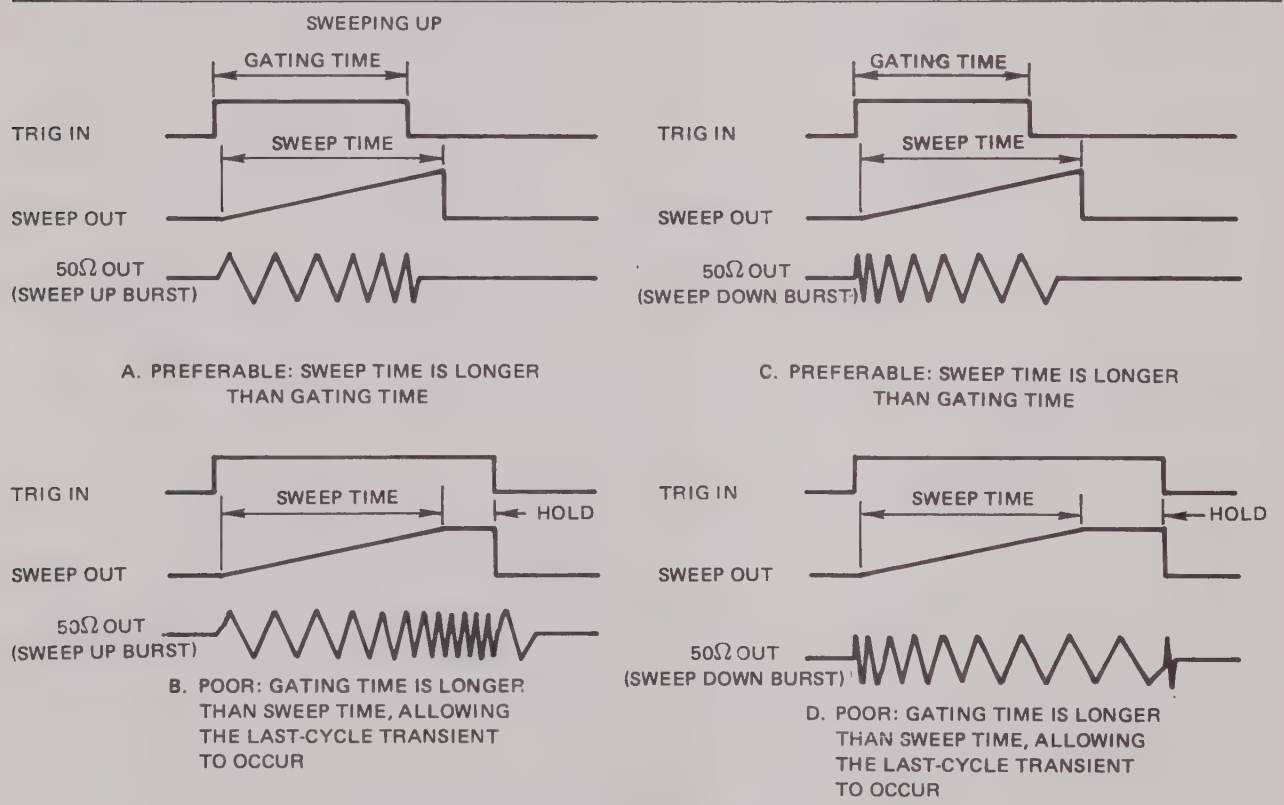


Figure 2-12. Sweep Burst Operation

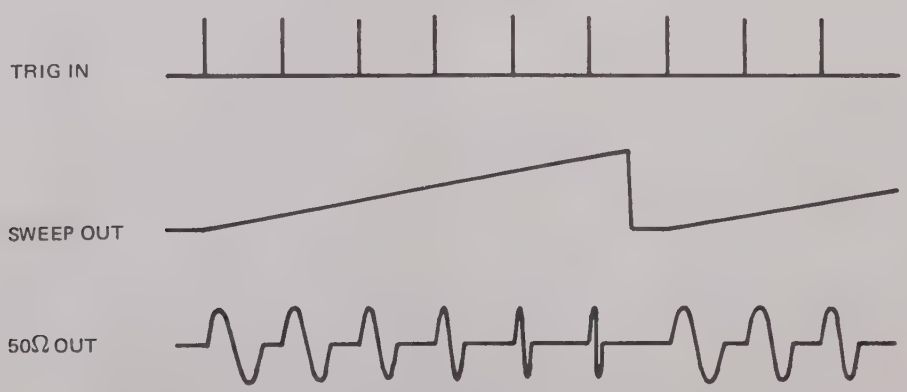


Figure 2-13. A Special Case of Sweep Burst Operation

SECTION 3
CIRCUIT DESCRIPTION

3.1 INTRODUCTION

This section provides a circuit description of the Model 164 generator for the understanding of its principles of operation. The paragraphs are grouped under six major categories. These categories are arranged in the sequence of first understanding the heart of the generator, and then examining the circuits that influence it and the circuits that it in turn influences.

The major circuit blocks that make up the generator are introduced in all capital letters. These blocks relate to the functional block diagrams of the main circuit board shown in Figure 3-3, and the sweep circuit board shown in Figure 3-4 at the back of this section. The circuit blocks are also identified on the appropriate schematic diagrams in Section 6.

3.2 BASIC WAVEFORM AND FREQUENCY DEVELOPMENT

The heart of the generator is a triangle and square wave generator. The triangle waves are developed by capacitor-charging ramps that are alternately reversed in polarity. The polarity reversal is caused by a flip-flop circuit that in turn produces the square waves. The flip-flop, or HYSTERESIS SWITCH changes states upon detecting amplitude limits of the charging ramps thru TRIANGLE AMPLIFIER NO. 1.

3.3 WAVEFORM DEVELOPMENT AND SELECTION

The WAVEFORM SELECTOR switch determines which of eight waveforms is to be output from the generator. A dc level can also be selected for output.

The triangle wave from triangle amplifier No. 1 is coupled thru unity gain TRIANGLE AMPLIFIER NO. 2 and made available to the waveform selector switch. Triangle amplifier No. 2 compensates for the output of amplifier No. 1 not having a low enough impedance to drive several other circuits. Triangle amplifier No. 2 provides the inputs for developing the sine and trapezoid waves. The SINE CONVERTER converts the triangle wave into a sine wave and makes it available to the waveform selector switch.

The square wave from the hysteresis switch and the triangle wave from triangle amplifier No. 2 are selected for input to the SQUARE & TRAPEZOID AMPLIFIER. With the square wave as input, the amplifier develops the square wave for output, as well as positive rectangular pulse and a negative rectangular pulse. The rectangular pulses result from rectifying either polarity of the square wave. With the triangle wave as input, the amplifier develops the trapezoid wave, a positive trapezoid pulse, and a negative trapezoid pulse. Similar to the rectangular pulses, the trapezoid pulses result from rectifying the trapezoid wave. The trapezoid wave is developed by a controlled overdriving of the triangle wave amplitude, the positive and negative peaks of the triangle being clipped. The SLOPE control determines the gain of triangle amplitude overdriving (see Figure 3-1). The WIDTH control determines the offset of the "amplitude window" between the clipped peaks (see Figure 3-2). The waveforms from the square & trapezoid amplifier are made available to the waveform selector switch.

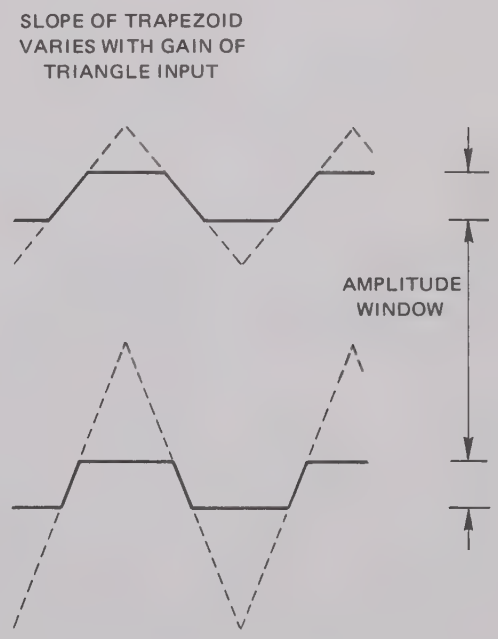


Figure 3-1. Trapezoid Slope Control

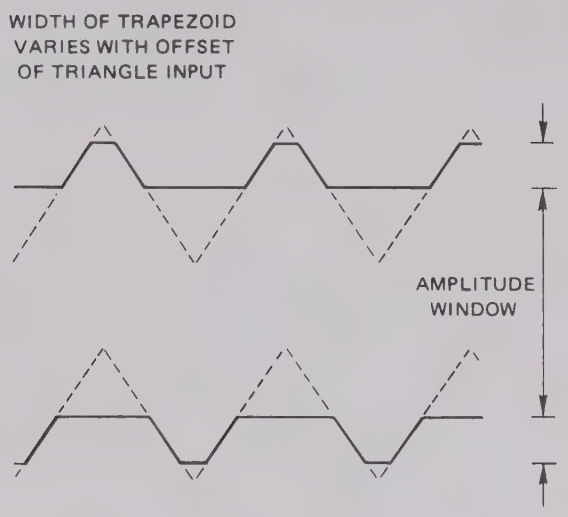


Figure 3-2. Trapezoid Width Control

The square wave from the hysteresis switch thru the SYNC AMPLIFIER is externally available at the SYNC OUT connector. The sync pulse, then, is a constant amplitude, square wave output of the generator's frequency and time symmetry.

3.4 FREQUENCY AND PERIOD CONTROL

The frequency of the waveforms is determined by selecting particular TIMING CAPACITORS to develop the triangle wave charging ramps. For slower charging times, and thus lower frequencies, a CAPACITANCE MULTIPLIER is used. The capacitance multiplier absorbs precise amounts of charging current, thereby slowing down the charging times.

The DIODE GATE supplies the appropriate polarity of charging current to the timing capacitors. Current is alternately switched from the POSITIVE CURRENT GENERATOR and then the NEGATIVE CURRENT GENERATOR with each alternation of the hysteresis switch square wave.

Waveform time symmetry is controlled by increasing or decreasing the two current sources relative to each other. Unequal charging currents thereby generate triangle wave ramps with unequal slopes. The current sources are normally equal in the amount of current supplied. The SYMMETRY CONTROL AMPLIFIER, however, can be switched into the circuit to allow setting an unbalance of the current sources' reference voltages. When this asymmetry is selected, frequency is divided by ten due to the supply limits of the current generators.

The input control voltage to the symmetry control amplifier and both current generators is provided by the VCG AMPLIFIER. Voltages from the FREQUENCY DIAL, the FREQUENCY VERNIER, the VCG IN connector, and the SWEEP CIRCUITS are summed together to determine the frequency control voltage from the VCG amplifier. The control voltage thru the GCV AMPLIFIER is externally available at the GCV OUT connector.

3.5 AMPLITUDE OFFSET AND ATTENUATION

The selected waveform is inverted and approximately doubled thru the PREAMPLIFIER. The VARIABLE output attenuator control provides up to 20 dB of attenuation of the waveform at the generator's output. Positive or negative reference level offset can be selected by the DC OFFSET control. The VARIABLE dc offset control provides the actual amount of offset to the selected waveforms center reference. The amount of dc offset can be affected externally at the EXT DC OFFSET connector.

The preamplifier waveform is again amplified by the OUTPUT AMPLIFIER. The output amplifier is also an inverting amplifier, only with a current limiting output stage for short circuit protection. The output amplifier establishes the generator's 0 dB attenuation reference. Two output attenuator stages decrease this reference amplitude in operator selected 10 dB steps down to −60 dB, attenuation between the steps provided from the variable output attenuator control of the preamplifier. OUTPUT ATTENUATOR NO. 1 provides the −10 dB, −20 dB, and −30 dB attenuation ranges. OUTPUT ATTENUATOR NO. 2 is switched in to provide an additional 30 dB attenuation for the −40 dB, −50 dB, and −60 dB ranges. The ATTENUATION SELECTOR switch determines if the attenuators are to be bypassed for the 0 dB range, if just output attenuator No. 1 is to be used, or if both output attenuators are to be employed for the generator's output.

3.6 TRIGGER AND GATED CONTROL

The enabling of generator operation is controlled by allowing or preventing the selected timing capacitor to charge. For continuous operation, the TRIGGER AMPLIFIER maintains a positive level above the positive peak developed by the charging capacitors. This reverse biases (turns off) the START/STOP DIODE SWITCH, preventing the trigger amplifier from affecting continuous operation.

When the trigger amplifier outputs some level below the positive peak charging level, the diode switch is forward biased (turned on) to hold the charging level constant. Preventing the capacitors to charge to the positive peak stops operation and holds the output at some dc level called the trigger baseline. The trigger baseline is thus the

level from which a waveform cycle starts and at where it will stop.

The normal trigger baseline is zero volt, analogous to 0° phase of a waveform. The TRIGGER START/STOP control offsets the trigger amplifier output and thus the baseline for starting and stopping a waveform from its negative peak (−90°) to its positive peak (+90°). Upon reaching the positive peak level, though, the diode switch again reverse biases and operation becomes continuous.

When the charging level is being held, the positive current generator still varies its output with corresponding frequency control inputs. These varying currents must be taken up thru the diode switch to keep the timing capacitors from varying their charge, and thus the trigger baseline. The BASELINE COMPENSATION circuit monitors the output from the positive current generator to control the trigger amplifier, and thus the necessary compensating current thru the diode switch.

The TRIGGER CONTROL LOGIC determines that after a waveform starts, it always stops at a complete cycle at the same phase at which it started. The trigger control logic latches the trigger amplifier for an enabling output from the time the cycle starts to when the negative peak of the last cycle is reached (just one cycle in the trigger mode). Upon reaching the negative peak, the timing capacitor continues charging positive again as usual but stops upon reaching the trigger baseline. A square wave from the hysteresis switch synchronizes the last negative peak time for unlatching the trigger amplifier for its trigger baseline output.

The GENERATOR MODE CONTROL circuit determines whether the trigger control logic is to be "fired" for just one cycle, or is to be held on for the duration of the trigger level input. When in a gated mode, the trigger level is directly coupled for controlling the trigger control logic. In the trigger mode, the trigger level is capacitively coupled to provide a leading edge spike to "fire" the trigger control logic.

The SQUARING CIRCUIT is a level detector that generates a square pulse for the duration of a trigger level at the TRIG IN connector. The pulse is also generated for the duration of the MAN TRIG switch being held down.

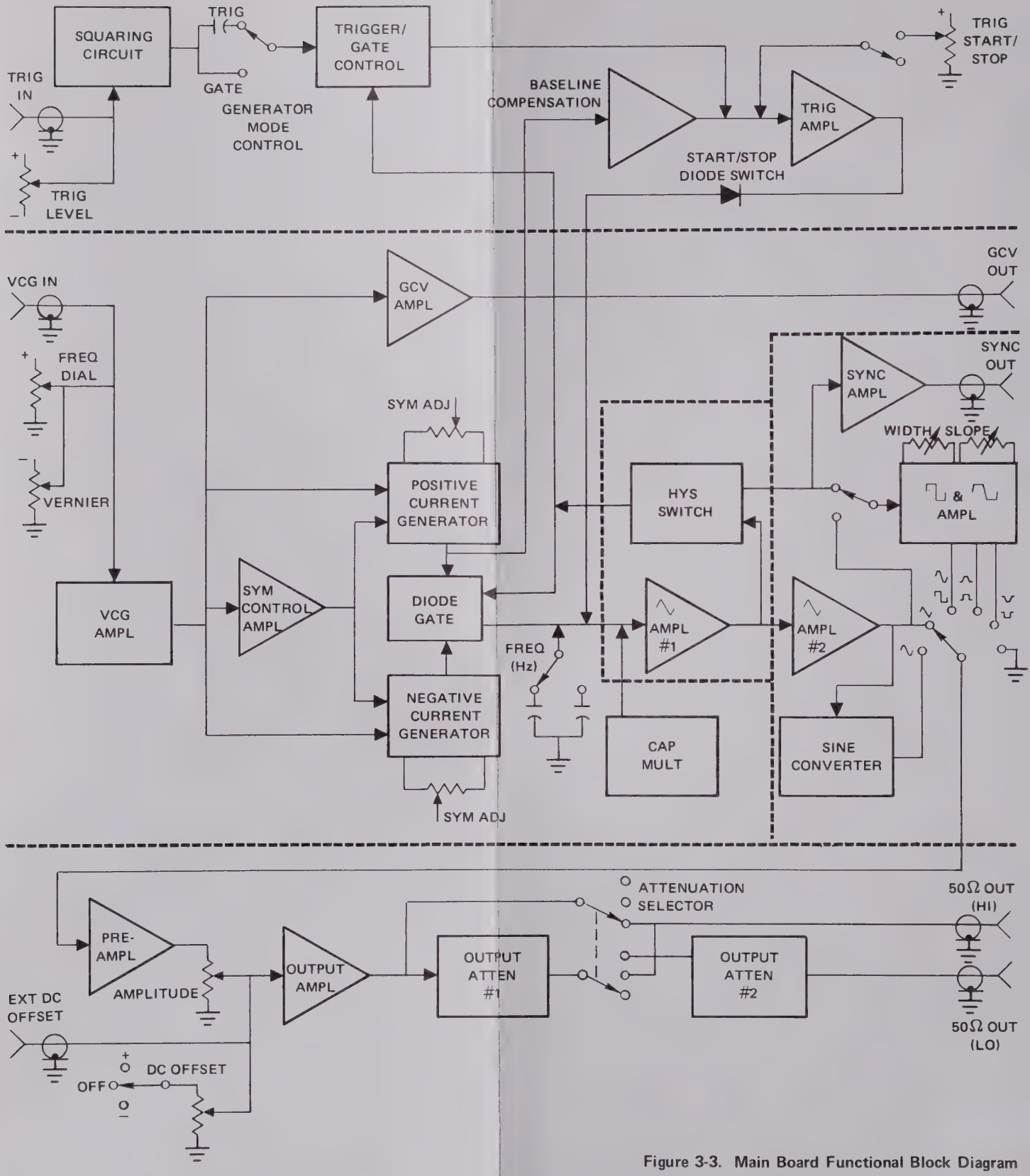


Figure 3-3. Main Board Functional Block Diagram

3.7 SWEEP CIRCUITS

The basic sweep generator consists of the current source, FET amplifier, clamping circuit, and hysteresis switch. See foldout Figure 3-4.

The current source charges capacitor C with a constant current I which produces a voltage ramp across C. The ramp is buffered by the FET amplifier and applied to the hysteresis switch. When the ramp reaches the threshold voltage of the hysteresis switch it changes state and discharges C very quickly thru the discharge diode. The clamping circuit clamps the peaks of the ramp to precise levels which assume 1000:1 sweep control.

For triggered and gated modes the entire generator may be either triggered or gated by the gating control logic circuit.

The step generator consists of the binary counter, state 10 decoder, step control logic, "and" gate, and the 4 bit D/A converter.

When in the step mode the entire ramp generator acts as a gated clock oscillator for the digital circuitry. In the continuous mode, clock pulses pass thru the "and" gate and cause the binary counter to increment up to state 10 and then reset. Each binary state is converted to an analog voltage by the D/A converter.

The D/A output is a staircase waveform.

In the triggered step mode, the step control logic causes the ramp generator to produce only 11 clock pulses which produces one cycle of the staircase. In the step hold mode, after state 10 is reached the "and" gate inhibits the counter until the trigger input signal goes low. On the next clock pulse the staircase resets.

Either the ramp or the staircase output is applied to two unity gain inverting amplifiers connected in cascade. This allows selection of either the normal or inverted waveform of ramp or staircase to drive the VCG circuit for sweeping up or down, respectively.

The normal positive going waveform is available at the sweep output connector.

SECTION 4
PERFORMANCE VERIFICATION AND CALIBRATION

4.1 INTRODUCTION

This section provides instructions for verifying the performance of, and calibrating the Model 164 generator. The instructions are concise and written for the experienced electronics technician or field engineer. Performance is verified when the desired result of an adjustment is already present.

4.2 FACTORY REPAIR

Wavetek maintains a factory repair department for those customers not possessing the necessary personnel or test equipment to maintain the instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached to minimize turnaround time.

4.3 RECOMMENDED TEST EQUIPMENT

The following test equipment is recommended.

1. Oscilloscope: Tektronix Model 7704 or equivalent with
   a. High frequency amplifier (7A13)
   b. Differential amplifier (7A11) (250 MHz BW)
2. Distortion Analyzer: HP334A or equivalent
3. Spectrum Analyzer: > 600 kHz
4. Five-digit Frequency Counter: > 30 MHz

4.4 ACCESS INSTRUCTIONS

The Model 164 is packaged so that it can be quickly disassembled to afford access to the majority of components within the unit, while allowing the instrument to be operated.

To remove the dust cover (case) from the Model 164, the following procedure should be followed:

1. Unplug the ac line cord and unscrew the four captive screws on the rear panel.
2. Remove the rear panel and power supply.
3. Unplug power supply connector from power supply board. Slide dust cover off slowly.
4. At this time, the power supply can be remounted and the Model 164 may be operated normally.

4.5 CALIBRATION INSTRUCTIONS

The following paragraphs provide complete sequential calibration procedures for the Model 164 instrument. Calibration of the generator is organized in a sequence of seven major groups. Each major group is a sequence of certain of the 30 individual selections and adjustments as listed below. The various calibration adjustments are located on either the Main Board PC Assembly or the Sweep Board PC Assembly as identified in foldout Figures 4-5 and 4-6, respectively, at the end of this section. Each calibration adjustment is independent of its following adjustment settings; an adjustment is, however, dependent on previous adjustment settings.

CALIBRATION ADJUSTMENT SEQUENCE

Paragraph	Calibration Sequence	Adjustment Sequence
Power Supply		
4.5.2	Power Supply Regulation	R10
Main Board		
4.5.3	Triangle Offset and Amplitude	R282, R370, R51, R142, R231, R106, R111, R124
4.5.4	Time Symmetry	R29, R39
4.5.5	Sine Distortion	R352, R368, R142, R369
4.5.6	Frequency	R15, C64, C65, R19, R12, R9, R20, C62, R18, R17, R16, R10, R74, R68, R66
4.5.7	Square Wave Purity	R279, C110
Sweep Board		
4.5.8	Sweep Circuit	R24, R19, R72, R71

4.5.1 Preliminary Procedures

Keep the generator covered and allow the unit to warm up for at least 30 minutes before calibration. Start the calibration by setting the front panel controls as follows:

FREQ (Hz)	X1K
Frequency Dial	1.0
FREQ (Hz) VERNIER	Maximum cw (CAL)
WAVEFORM	∿ (Sine)
OUTPUT ATTEN (dB)	−10
OUTPUT ATTEN (dB) VARIABLE	3/4 cw
SYMMETRY	OFF
DC OFFSET	OFF
GEN MODE	CONT
TRIG START/STOP	0° CAL
SWEEP/STEP TIME	OFF

4.5.2 Power Supply Regulation

1. Before connecting the unit to an ac source, check the ac line voltage. To make sure the 115/230 and HI/LO switches are set at the correct position, refer to Paragraph 2.2.1.

2. Connect ac power and turn on the generator. Connect a voltmeter ground lead to TP1 (common) and the other lead to TP2 (+15 V) on the main circuit board (see foldout Figure 4-5).

3. Adjust potentiometer R10 in the power supply assembly to obtain +15 Vdc ±20 mV at TP2. The power supply assembly is at the rear of the unit; the potentiometer, although located on the inner side of the printed circuit board, can be seen. Adjust by finger pressure.

4. Check voltage at TP3 for −15 Vdc ±50 mV, at TP4 for +24 Vdc ±400 mV, and at TP5 for −24 Vdc ±400 mV.

5. Check voltage at TP6 for +5 Vdc ±250 mV.

4.5.3 Triangle Offset and Amplitude Adjustment

1. Set the WAVEFORM selector to DC, the OUTPUT ATTEN switch to 0 dB, the OUTPUT ATTEN VARIABLE control to maximum ccw, and the GEN MODE switch to TRIG.

2. Connect the 50Ω OUT (HI) to the oscilloscope and load with a 50Ω terminator.

3. Adjust R282 to obtain output dc voltage of less than ±5 mV.

4. Set the OUTPUT ATTEN VARIABLE control to maximum cw.

NOTE

DC level may change between full cw and full ccw.

5. Adjust R370 to obtain output dc voltage of less than ±5 mV.

6. Repeat Steps 3 thru 5 once.

7. Rotate the frequency dial from 0.03 to 3.0 and adjust R51 for minimum change of output voltage, shifting less than 50 mV typically.

8. Set the frequency dial to 1.0, the WAVEFORM selector to ∿ , and the GEN MODE switch to TRIG.

9. Use voltage at TP7 as reference; adjust R142 until voltage at TP8 equals the voltage at TP7 to within 10 mV.

10. Adjust R231 to obtain 0 Vdc ±10 mV at 50Ω OUT (HI).

11. Set GEN MODE switch to CONT, and set frequency at 1 kHz (1.0 X 1K). Connect the differential oscilloscope to TP8 and ground at TP1.

12. Adjust R106 to make the negative peak of the waveform −1.250 V ±10 mV.

NOTE

As the frequency is increased, the signal will become flatter; as the frequency is decreased, the signal will look more like a ∿ .

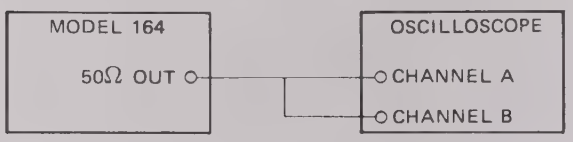
13. Connect the oscilloscope probe to TP9, and adjust R111 to make the ∿ waveform (approximately a 5 mV p-p signal) average voltage 0 V.

14. Adjust R124 for the square waveform at TP10 symmetrical above ground ±200 mV.

4.5.4 Time Symmetry Adjustment

1. Set the frequency dial to maximum cw, the FREQ (Hz) switch to X 100K and the WAVEFORM selector to ⊓⊔ . Connect 50Ω OUT (HI) to the oscilloscope.

2. Set the oscilloscope time base to 0.2 ms/division. Adjust the FREQ VERNIER control until the oscilloscope screen is filled by approximately one cycle (see setup and display in Figure 4-1).



Frequency:	500 Hz
Waveform:	
Symmetry:	= 100 a/b%
Time Base:	0.2 ms/division
Sweep Magnified:	X 10
Trigger:	Internal and Alternate
Channel A:	Normal
Channel B:	Inverted

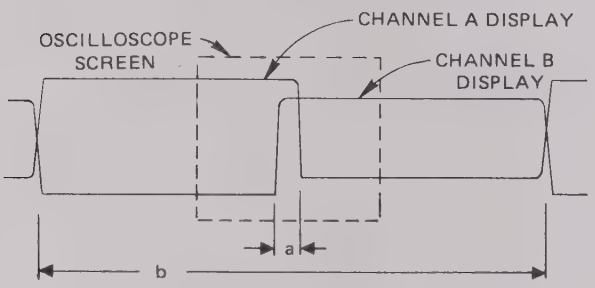


Figure 4-1. Alternate Time Symmetry Test Setup

3. Switch the oscilloscope trigger from + to −, and adjust R29 to obtain ⊓⊔ waveform time symmetry to within 0.5% (= 2 μs for 500 Hz).

4. Set the frequency dial to 2.0 and FREQ (Hz) to X 1K.
5. Set the oscilloscope time base to 50 μs. Use a similar procedure as above, and adjust R39 to obtain ⊓⊔ waveform time symmetry to within 0.1% (= 0.5 μs for 2 kHz.
6. Repeat Steps 1 thru 3 once.

4.5.5 Sine Distortion Adjustment

1. Set the FREQ (Hz) switch to X1K, the frequency dial to 1.0 and the WAVEFORM selector to ∿ . Connect the 50Ω OUT (HI) to a distortion analyzer loaded with a 50Ω terminator. (See Figure 4-2 for test setup.)

2. Adjust R368 and R369 for minimum sine distortion, less than 0.15%. It may be necessary to reset R142 to achieve minimum sine distortion. R142 also affects the ⩛ waveform offset.) Repeat Steps 7 and 9 of Paragraph 4.5.3 (Triangle Offset and Amplitude Adjustment).

NOTE

Trim resistor R351 may be changed for minimum sine distortion. Typical values are 825Ω and 909Ω.

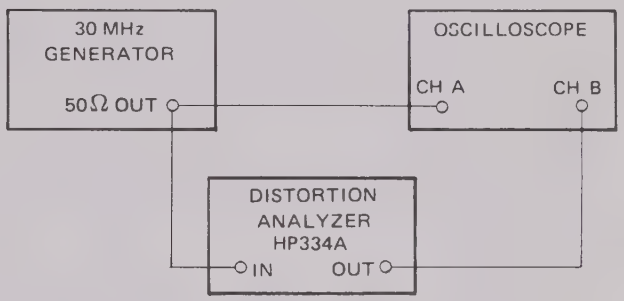


Figure 4-2. Distortion Test Setup

4.5.6 Frequency Calibration

1. Set the FREQ (Hz) switch to X 100K, the frequency dial to 0.03, the FREQ VERNIER maximum cw (CAL), and the WAVEFORM selector to ⊓⊔ . Connect 50Ω OUT (HI) to the oscilloscope.

2. Alternately short and open the VCG IN connector between its input and ground and adjust R15 at the same time until no observable frequency shift is seen on the oscilloscope.

3. Set the FREQ (Hz) switch to X 10M and the frequency dial to 2.0 Adjust C64 to obtain an output frequency of 20 MHz ±100 kHz. Select a different value of C65 if calibration cannot be achieved; each addition of 1 pF will reduce frequency by 200 kHz.

4. Set the FREQ (Hz) switch to 100K and the frequency dial to 3.0. Adjust R19 to obtain an output frequency of 300 kHz ±600 Hz.

NOTE

Select different value of R12 if frequency calibration in Steps 4, 9, and 10 cannot be achieved. Also, start from Step 3 again.

5. Set the frequency dial to 0.03 and the FREQ VERNIER control to maximum ccw. Adjust R9 to obtain an output frequency of 200 Hz ±20 Hz.

6. Repeat Steps 4 and 5 once.

7. Set the FREQ (Hz) switch to X 1M, the frequency dial to 3.0 and the FREQ VERNIER control to maximum cw (CAL). Adjust R20 to obtain an output frequency of 3 MHz ±10 kHz. Select a different value of C62 if calibration cannot be achieved; each addition of 10 pF will reduce frequency by 30 kHz.

8. Repeat Steps 3 and 7 once.

9. Set the FREQ (Hz) switch to X 10K. Adjust R18 to obtain an output frequency of 30 kHz ±60 Hz. (Refer to Note in Step 4.)

10. Set the FREQ (Hz) switch to X 1K. Adjust R17 to obtain an output frequency of 3 kHz ±6 Hz. (Refer to Note in Step 4.)

11. Set the FREQ (Hz) switch to X 100. Adjust R16 to obtain an output frequency of 300 Hz ±0.6 Hz (3.33 ms ±6 μs). Select a different value of R10 if calibration cannot be achieved.

12. Set the FREQ (Hz) switch to X 10 and the frequency dial to 0.1. Adjust R74 to obtain time symmetry of the ⊓⊔ waveform output better than 0.1%. Refer to Paragraph 4.5.4 (Time Symmetry Adjustment) for setup and measurement.

13. Set the frequency dial to 3.0. Adjust R68 to obtain an output frequency of 30 Hz ±0.06 Hz (33.3 ms ±6.0 μs). Check frequency accuracy at X 1 and X 0.1 ranges for better than 1%, or readjust R68. Select a different value of R66 if calibration cannot be achieved.

4.5.7 Square Wave Adjustment

1. Set the frequency dial to 1.0, the FREQ (Hz) switch to X 10K, the WAVEFORM selector to ⊓⊔ , and the OUTPUT ATTEN VERNIER to maximum cw. Adjust R279 to make the absolute negative peak voltage equal to the positive peak voltage within ±20 mV.

2. Set the FREQ (Hz) switch to X 1M. Adjust C110 to make a square waveform with the best square corner, but without overshoot.

4.5.8 Sweep Circuit Adjustment

1. Set the GEN MODE switch to TRIG SWP, the SWEEP MODE switch to STEP UP, the SWEEP/STEP TIME switch to OFF and the TRIG LEVEL control to maximum ccw.

2. Adjust sweep board potentiometer R24 for voltage between 0 mV and −2 mV at the SWEEP OUT connector.

3. Set the SWEEP/STEP TIME control to the 1 s/100 ms range. Adjust sweep board potentiometer R19 for voltage between 0 mV and −2 mV at the SWEEP OUT connector.

4. Set the GEN MODE switch to CONT SWP and the SWEEP MODE switch to RAMP UP. Connect the SWEEP OUT connector to the vertical input of the oscilloscope.

5. Turn the SWEEP/STEP TIME VARIABLE control fully cw. Adjust sweep board potentiometer R72 until the lower peak shows no flattening of the ramps, while still maintaining the lower peak at zero volt (see Figure 4-3).

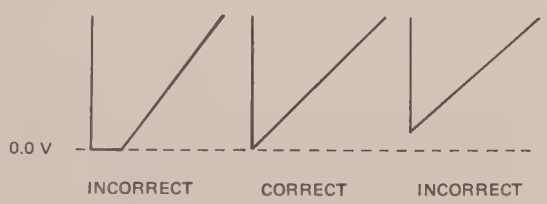


Figure 4-3. Ramp Negative Peak Adjustment

6. Adjust sweep board potentiometer R71 until the positive peak shows no flattening, but does not decrease in amplitude from the clipped level (see Figure 4-4).

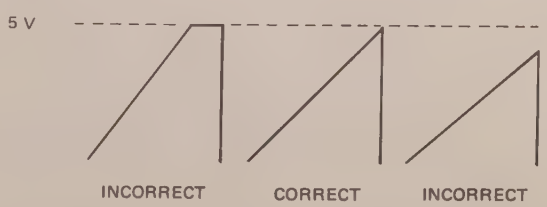


Figure 4-4. Ramp Positive Peak Adjustment

TEST POINT	FUNCTION
TP1	COM
TP2	+15V
TP3	-15V
TP4	+24V
TP5	-24V
TP6	+5V
TP7	$\sim V_1$
TP8	$\sim V_2$
TP9	$\sim V_{dc}$
TP10	⊓

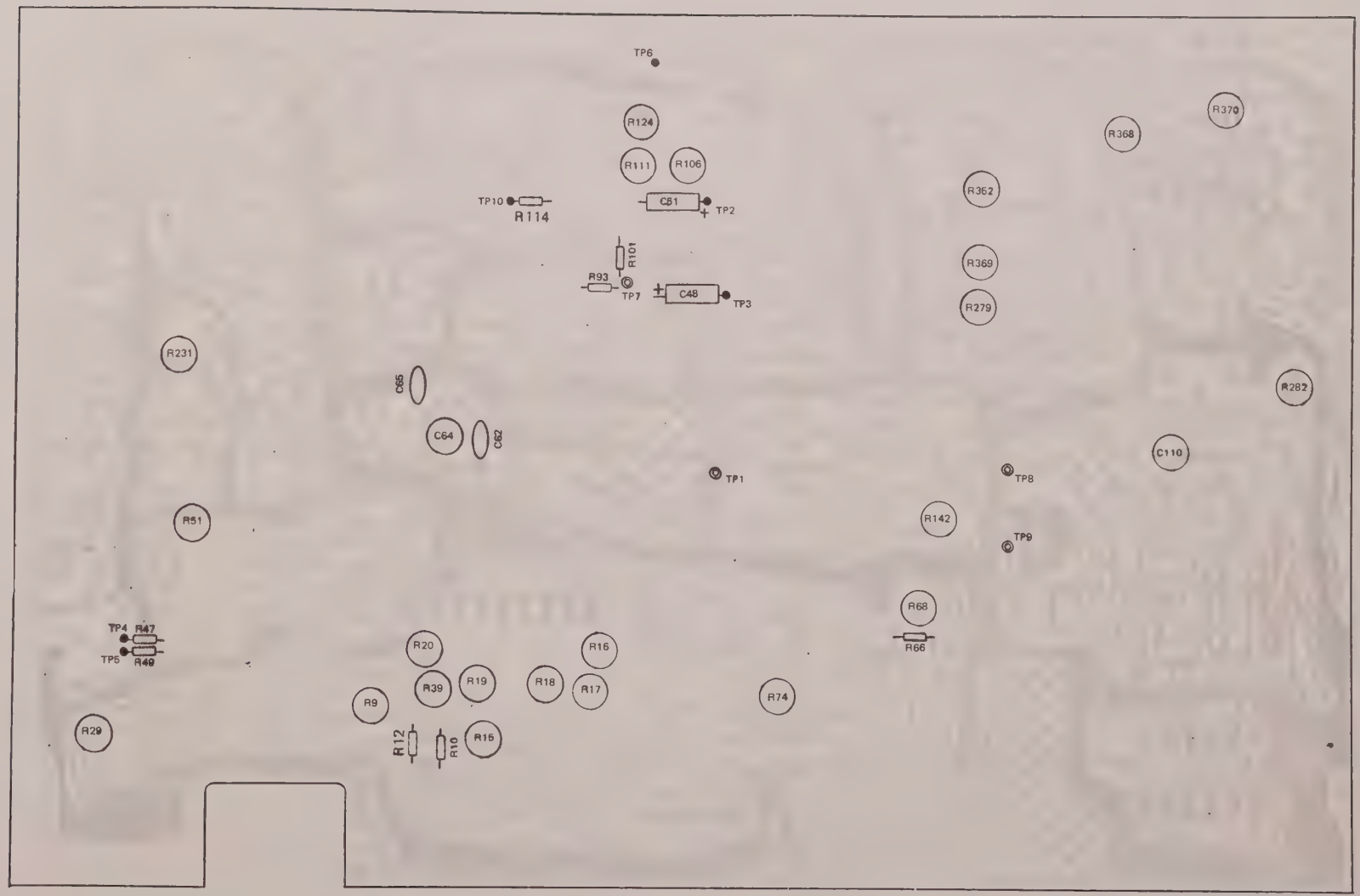


Figure 4-5. Main Circuit Board Calibration Components

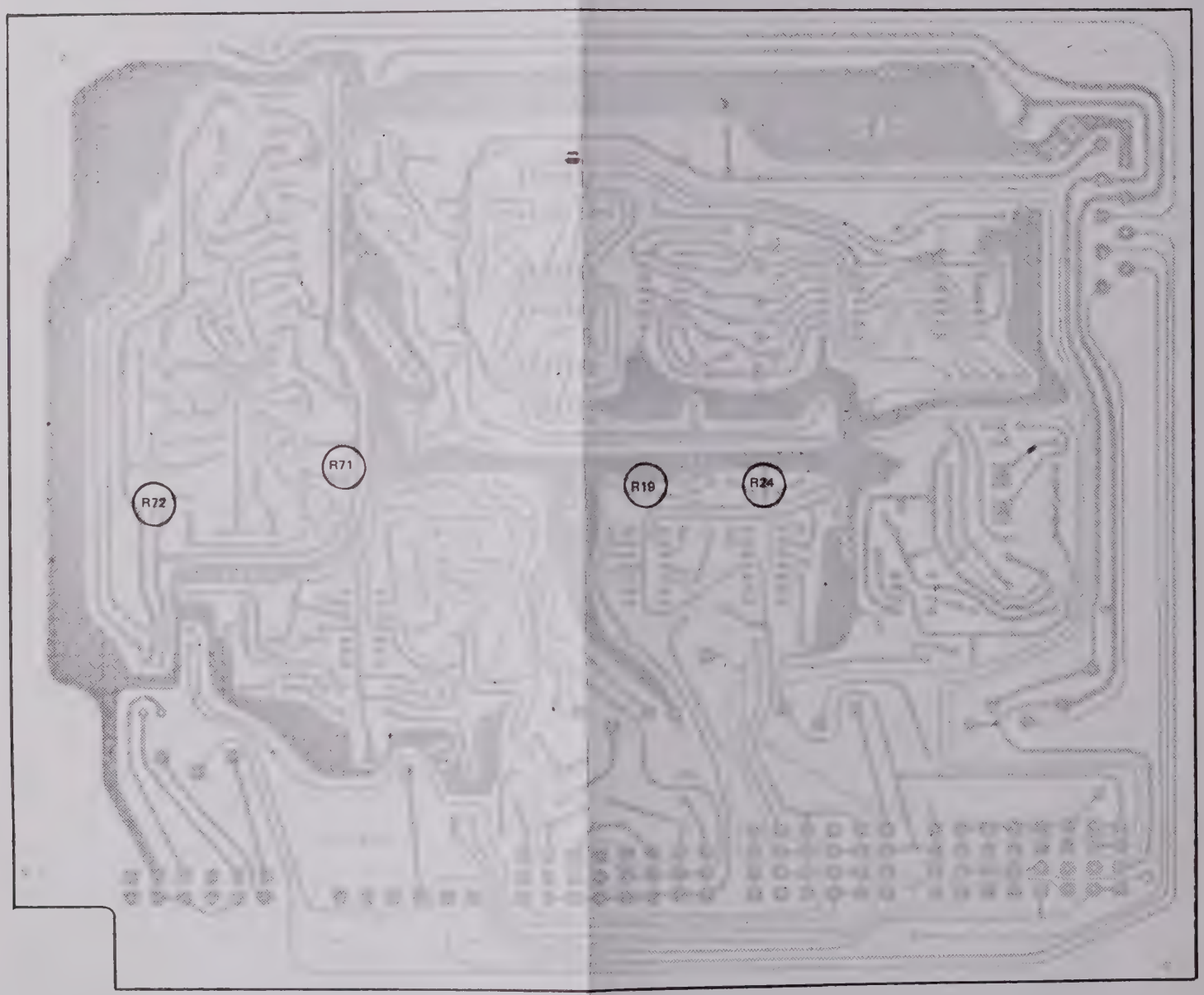


Figure 4-6. Sweep Board Calibration Components

SECTION 5
TROUBLESHOOTING

5.1 CORRECTIVE MAINTENANCE

This section presents a systematic approach to troubleshooting. The section is organized in three parts as follows:

Part 1 (5.2). Troubleshooting Technique for Individual Components. Frequently you can quickly locate a defective component by this technique without understanding the function of the circuit. It is also a necessary technique when extensive troubleshooting to component level is required.

Part 2 (5.3). Troubleshooting Guide. Start by observing the symptom of malfunctioning; then use the guide to find the defective component or malfunctioning circuit.

Part 3 (5.4). Troubleshooting Procedure for Individual Circuits. This is a supplemental procedure to Part 2 and used when Part 2 has failed to locate the defective components. However, procedure in Part 2 should always be checked first; usually, it will refer to a specific procedure in Part 3.

5.2 TROUBLESHOOTING TECHNIQUE FOR INDIVIDUAL COMPONENTS

5.2.1 Transistor

1. A transistor is defective if more than one volt is measured across its base emitter junction in the forward direction.

2. A transistor when used as a switch may have a few volts reverse bias voltage.

3. If the collector and emitter voltages are the same, but the base emitter voltage is less than 500 mV forward voltage (or reversed bias), the transistor is defective.

4. A transistor is defective if its base current is larger than 10% of its emitter current (calculate currents from voltage across the base and emitter series resistors).

5. In a transistor differential pair (common emitter stages), either their base voltages are the same in normal operating condition, or the one with less forward voltage across its base emitter junction should be OFF (no collector current); otherwise, one of the transistors is defective. Example, Q56A and Q56B.

5.2.2 Diode

1. A diode is defective if across it there is greater than one volt (typically 0.7 volt) forward voltage.

5.2.3 Operational Amplifier; e.g., UA741C, LM318

1. The "+" and "–" inputs of an OP AMP will have less than 15 mV voltage difference when operating under normal conditions.

2. If the output voltage stays at maximum positive, its "+" input voltage should be more positive than its "–" input voltage, or vice versa; otherwise, the OP AMP is defective.

3. The input of an OP AMP should not draw more than 500 mA of current (calculate current from voltage across its input series resistor) or it is defective.

5.2.4 FET Transistor

1. No gate current should be drawn by the gate of an FET transistor. If so, the transistor is defective.

2. The gate-to-source voltage is always reverse biased under a normal operating condition; e.g., the source voltage is more positive than the gate voltage for 2N5485 and TP308, and the source voltage is more negative than gate voltage for a 2N5462. Otherwise, the FET is defective.

5.2.5 Capacitor

1. Shorted capacitors have zero volts across their terminals.

2. Opened capacitor can be located (but not always) by using a good capacitor connected in parallel with the capacitor under test and observing the resulting effect.

5.3 TROUBLESHOOTING GUIDE FOR MAIN CIRCUITS

The following troubleshooting guide is a list of possible malfunction symptoms, their probable causes, and prescribed remedies. To use the guide, locate the symptom listed and follow the corresponding procedures to locate the fault. If more intensive test is required to locate the fault, the guide will refer to a more specific procedure.

	SYMPTOM	CORRECTIVE PROCEDURES
A.	**Output Waveform Problem**	
1.	Generator dead, blown fuse.	a. Replace fuse F1; if fuse blows again, refer to Paragraph 5.4.9.
2.	All output waveforms are distorted or are not output, but SYNC OUT is normal.	a. Set OUTPUT ATTEN to 0 dB and DC OFFSET VARIABLE to MIN (ccw). b. If output voltage can be adjusted to ±10 V into open circuit with the DC OFFSET control, problem is in the preamplifier; refer to Paragraph 5.4.5. c. Otherwise, problem is in the output amplifier; also refer to Paragraph 5.4.5.
3.	Power is on, but no output waveform at 50Ω OUT and SYNC OUT (GEN MODE at CONT).	a. Check for normal power supply voltage. b. Check the triangle generator circuits; refer to Paragraph 5.4.3.
4.	Waveform amplitude and frequency jittering.	a. Power supply out of regulation due to ac line voltage being too low. Check line voltage and make sure the HI/LO switch setting in the power supply module is correct. b. Malfunctioning power supply; refer to Paragraphs 5.4.10 and 5.4.11.
B.	**Problems in General (Distortion, Oscillation, High Frequency Roll Off, etc.)**	
1.	Problem appears in all waveforms, but SYNC OUT is normal.	a. Problem is in the output amplifier if problem is not seen at junction of R392 and R394. b. Otherwise, problem is in the preamplifier; refer to Paragraphs 5.4.5 and 5.4.7. *(Note: Most oscillation and high frequency roll off problems are caused by defective capacitors.)*
2.	Sine waveform problem only.	a. Problem is in the sine converter. C125 and C126 are shorted if no sine output; also refer to Step C.
3.	Square waveform problem only.	a. Defective Q45, Q49, CR37, CR40 or the associated components, and switch wafer.
4.	Trapezoidal waveform problem only.	a. Defective Q46, Q47, Q48, CR38, CR39 or the associated components, switch wafer, and controls.
5.	Both square and trapezoidal waveform problems.	a. Defective Q50 - Q53, CR41 - CR48, and the associated components.
6.	Trapezoidal WIDTH control problem.	a. Defective C95, R260 - R262 or the control potentiometer.
7.	Trapezoidal SLOPE control problem.	a. Defective control potentiometer, R253 - R256.
8.	Problem with triangle and sine waveforms only (or also trapezoidal).	a. Malfunctioning triangle No. 2; refer to Paragraphs 5.4.5 and 5.4.6. *(Note: High frequency roll off may be due to defective C44 - C49.)*

	SYMPTOM	CORRECTIVE PROCEDURES
9.	Problem in SYNC OUT.	a. Q25 - Q27 or the associated circuitry.
10.	Problem in SYNC OUT and square waveform OUT.	a. Defective Q16.
11.	Distorted waveform, or generator not running when X .001 Hz to X 10 Hz is selected.	a. Problem in capacitance multiplier; refer to Paragraph 5.4.4.
C.	**Sine Distortion Problem**	
1.	Distortion OK at 1 kHz, but out of specification at 10 kHz and/or 100 kHz.	a. Due to the triangle, amplitude into the sine converter is varied. Check for defective C33 - C36, C41 and the associated resistors.
2.	Distortion out of specification in one or more frequency ranges.	a. Defective timing capacitor C53 - C62. In this case, triangle waveform will show nonlinear slope and distorted peak.
3.	Distortion out of specification due to distorted or unsymmetrical triangle.	a. If the leakage current of Q9, C22, C65, and C64 is large, it will cause nonlinear triangle and sine distortion in all frequencies. b. Distortion is caused by out-of-calibration or malfunctioning current generator if square wave time symmetry is off by more than 0.5%.
4.	Half of the sine waveform is missing.	a. Defective R368 or R369.
5.	Triangle waveform normal, but sine waveform distorted.	a. Check for normal triangle at sine converter input. It should be ±1.25 V p-p, and have better than 0.5% time symmetry and linear slope. b. If no defective resistor is found, replace the diode set CR54 - CR65.
6.	Distortion out of specification at frequencies greater than 1 MHz.	a. Problem is in the triangle amplifier No. 1 and hysteresis switch if frequency accuracy at X 10 MHz range is also out of specification. b. Check for defective capacitors, CR9 and CR10. c. Problem is in the preamplifier and output amplifier if square wave rise/fall time also does not meet the specification. Check for defective capacitor in the circuit. d. Defective CR14 - CR17, C22, C65 and C64. e. Defective C10 - C13, which may also cause frequency jumping when dial is rotated slowly (at X 10 MHz).
D.	**Time Symmetry Problem**	
1.	Positive slope of triangle remains constant when frequency dial is varied.	a. Defective IC3, IC6, Q1, Q3, Q5, C7 and the associated circuitry.
2.	Negative slope of triangle remains constant when frequency dial is varied.	a. Defective IC5, IC7, Q2, Q4, Q6, and the associated circuitry.
3.	Symmetry off a few percent at 3.0 of dial, but not much worse at .03 of dial.	a. R39 is out of calibration or defective. b. Defective R38, R40, R41, R46, R50, R53, or R59.

	SYMPTOM	CORRECTIVE PROCEDURES
4.	Symmetry off only if dial is set close to, or above 3.0.	a. IC5 is saturated due to frequency being out of calibration. b. IDSS (drain current, source shorted) of Q2 is too small; select a 2N5462 with IDSS of 3 mA.
5.	Symmetry off, several times worse if frequency dial and vernier is set to minimum.	a. Defective Q9, Q3, Q5, C10, CR15 or CR16 if the triangle at 50Ω OUT rises faster than it falls. b. Defective Q4, Q6, C11, CR14 or CR17 if the triangle at 50Ω OUT falls faster than it rises.
6.	Symmetry is out of specification at X 10 frequency range, and gets proportionally worse as frequency is decreased.	a. Defective Q8. b. R74 is out of calibration.
E.	**Waveform Problem**	
1.	Nonlinear or distorted triangle at one particular frequency range.	a. Check for defective frequency range capacitor C53 - C62 or C18.
2.	Nonlinear or distorted triangle at all frequencies.	a. Check for defective C22, C26, C64, Q9, CR14 - CR17.
3.	Nonlinear triangle only at its peak.	a. R124 is out of calibration. b. Square wave at E of Q23, E of Q24 is not symmetrical about ground due to defective Q23, Q24, CR14 - CR17 or the associated circuitry.
4.	⌐⌙ rise/fall time abnormally slow; also, sine wave rolling off at high frequency. High frequency oscillation on all waveforms.	a. Check for defective capacitor in output amplifier if waveform at E of Q72 is normal. (Rise/fall time less than 10 ns.) b. Otherwise, check for defective capacitor in the preamplifier.
5.	Nonlinear triangle at low frequency (X 10 to X 0.001 range).	a. Defective C18. b. Defective Q8, IC9, IC10, and the associated circuitry.
F.	**Frequency Accuracy Problem**	
1.	Frequency out of specification even at X 1 kHz range.	a. Check for normal triangle waveform at E of Q11 (±1.25 V ±5 mV and time symmetry within 0.5%), at 3 kHz. b. Defective dial potentiometer or mismatched dial and potentiometer (numbers marked on the dial and potentiometer should be the same), if frequency is out of specification at the same portion of the dial in every range. c. Defective current generator, especially IC1, IC5 and Q2, if triangle is unsymmetrical.
2.	Frequency out of specification at X 10 kHz, X 100 kHz, or X 1 MHz ranges.	a. Check for defective C33 - C36, C41. b. Check for defective Q13.
3.	Frequency out of specification at X 10 MHz range.	a. Defective Q13. b. Defective C31, C32, C37, C38, C26, or C41. c. Check for defective CR9 and CR10 (to check, set frequency to 3 kHz and compare waveform at the diode as shown in Figure 5-1).

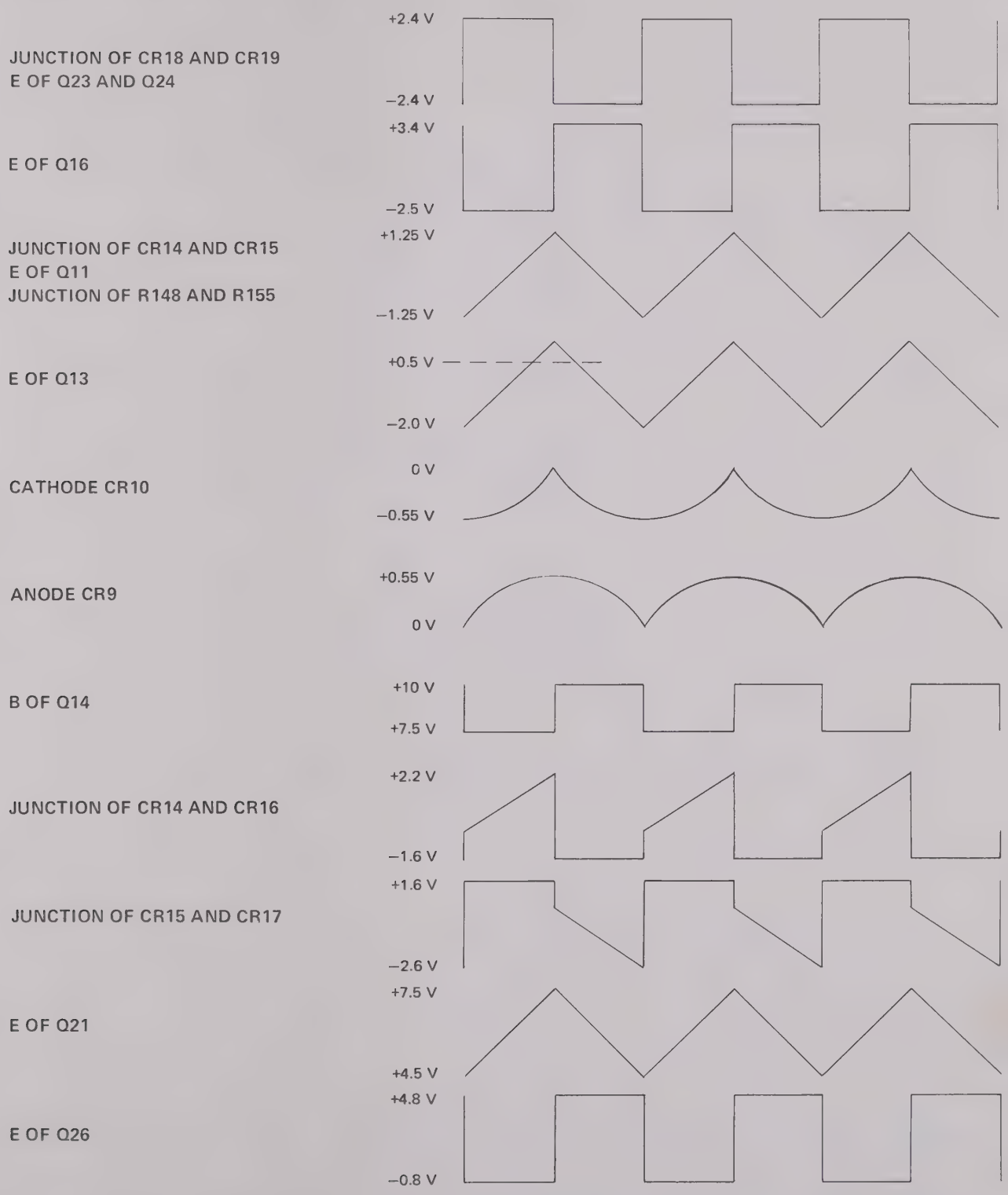


Figure 5-1. Key Waveforms of Amplifier No. 1, Amplifier No. 2, Comparator and Hysteresis Switch

	SYMPTOM	CORRECTIVE PROCEDURES
4.	Frequency out of specification at X .001 to X 10 Hz range.	a. Defective R77 - R81 or C18. b. Defective IC9, Q8, IC10 in the capacitance multiplier.
G.	**Generator Mode Problem**	
1.	Generator not running in CONT mode.	a. Problem is in trigger circuit if voltage at E of Q44 is +1.2 volts; refer to Paragraph 5.4.1. b. Otherwise, check for defective CR36.
2.	Generator runs continuously in all GEN modes.	a. TRIG START/STOP control is at VAR and its variable is set too far cw. b. Defective CR36 if voltage at E of Q44 is +1.2 volts when TRIG mode is selected. c. Otherwise, troubleshooting the trigger circuit is covered in Paragraph 5.4.1.
3.	Both TRIG and GATED modes work as if in GATED mode.	a. Defective Q33 or CR24. b. Check for defective GEN MODE switch wafer and circuit connection. c. Otherwise, troubleshooting the squaring circuit is covered in Paragraph 5.4.1B.
4.	Both TRIG and GATED modes work as if in TRIG mode.	a. Defective Q33 or C73. b. Otherwise, troubleshooting the squaring circuit is covered in Paragraph 5.4.1B.
5.	TRIG mode not working, but GATED mode OK.	a. Defective C76 or CR24.
6.	MAN TRIG not working.	a. Defective Q31, C77, CR23, C75 or the associated circuitry. b. Check MAN TRIG switch setting.
7.	TRIG LEVEL control has no affect, or loads the ±15 volt power supply down when set to its extremes.	a. Defective C72, R182, or wiring. b. Defective control potentiometer.
8.	TRIGGER START/STOP level (baseline) varies more than 100 mV, at maximum output voltage.	a. R51 is not properly calibrated. b. Defective IC8, Q7, and associated circuitry. c. Mismatched CR36 and CR4.
9.	High frequency oscillation on TRIGGER START/STOP level, or baseline.	a. Defective capacitor C82 - C87 in trigger amplifier.
10.	Generator does not trigger with high frequency trigger as specified.	a. Defective CR24, C71, or C75.
11.	Other trigger problems.	a. Refer to Paragraph 5.4.

5.4 TROUBLESHOOTING PROCEDURE FOR INDIVIDUAL CIRCUITS

The following is a step-by-step procedure for troubleshooting a circuit which is believed to be malfunctioning. Checking should always start from the first step of each section of the procedure. Depending on the test result of each step, continue the test in sequence as indicated under the TRUE/FALSE column until problem is corrected.

Example: In Step A3, from the test result, if voltage at emitter of Q34 is less than –0.1 volt, continue the test in Step A4; otherwise, go to Step B and continue the test at Step B1.

5.4.1 Troubleshooting of Trigger Circuit

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
A	**Quick Check of Trigger Circuit**		
A1	Set GEN MODE to GATED.	A2	
A2	Set TRIG LEVEL control fully ccw.	A3	
A3	Voltage at E of Q34 is less than −0.1 volt, greater than +3.5 volts with TRIG LEVEL fully cw. (Squaring circuit is OK if true.)	A4	B
A4	Voltage at E of Q40 is about +1.5 volts, −1.5 volts if TRIG LEVEL is fully cw.	A5	C
A5	Junction of R223 and R237 is zero volt. Also, E of Q44 is more positive than −2 volts but less positive than +0.6 volt.	A6	D
A6	Trigger circuit is working normally. Refer to Paragraph 5.3G for other trigger or gated mode problems.		
B	**Squaring Circuit Problem**		
B1	With TRIG LEVEL control fully ccw, CR24 is OFF (zero volt across it); fully cw, CR24 is ON (at least 0.5 volt across it).	B4	B2.1
B2	E of Q30 is about +5 volts.	B3	B3
B2.1	Defective Q30, R188, R189. May be due to extra loading, such as C74 being shorted.		
B3	E of Q31 is zero volt, but drops to −14 volts when MAN TRIG switch is depressed.	B4	B3.1
B3.1	Defective Q31, MAN TRIG switch, or the associated circuitry.		B3.2
B3.2	Check for defective Q28, Q29, CR24, and TRIG LEVEL control.		
B4	Voltage at junction of R201 and R199 is −15 V when CONT mode is selected; +15 V for TRIG mode, and +4.5 V for GATED mode.		
B4.1	Defective GEN MODE switch.		
B5	Select GATED mode. C of Q32 is +4 V if TRIG LEVEL is fully cw, but zero volt if fully ccw.	B6	B5.1
B5.1	Check for defective Q32 and Q33.		B6
B6	Defective Q34. *(Note: Q34 is a voltage follower.)*		A4
C	**Trigger Logic Circuit Problem**		
C1	Set GEN MODE to GATED, and TRIG LEVEL control fully ccw.	C2	
C2	Voltage across R204 is zero volt, more than 3 volts if CONT mode is selected.	C3	C2.1
C2.1	Defective Q35, R201, R202, switch wafer SW5-B, or connections.		
C3	Voltage at E of Q36 is about +2 volts, ⎍ waveform if TRIG LEVEL control is cw or CONT mode is selected.	C4	C3.1
C3.1	⎍ waveform is at E of Q36 in GATED mode with TRIG LEVEL fully ccw.	C4	C3.2
C3.2	Check for defective Q36, CR26 or C78. *(Note: Voltage at E of Q36 follows SYNC IN.)*		
C4	Voltage at E of Q40 is about +1.5 volts.	D	C4.1
C4.1	Check for defective CR27 and CR28.		C4.2
C4.2	Check for defective Q37 - Q40. *(Note: This circuit works like a flip-flop; Q37 and Q38 are alternately ON.)* Set TRIG LEVEL to cw or ccw, and check for correct voltage levels at E of Q37, Q39 and Q40 as shown in Figure 5-2 under GATED mode operation.		

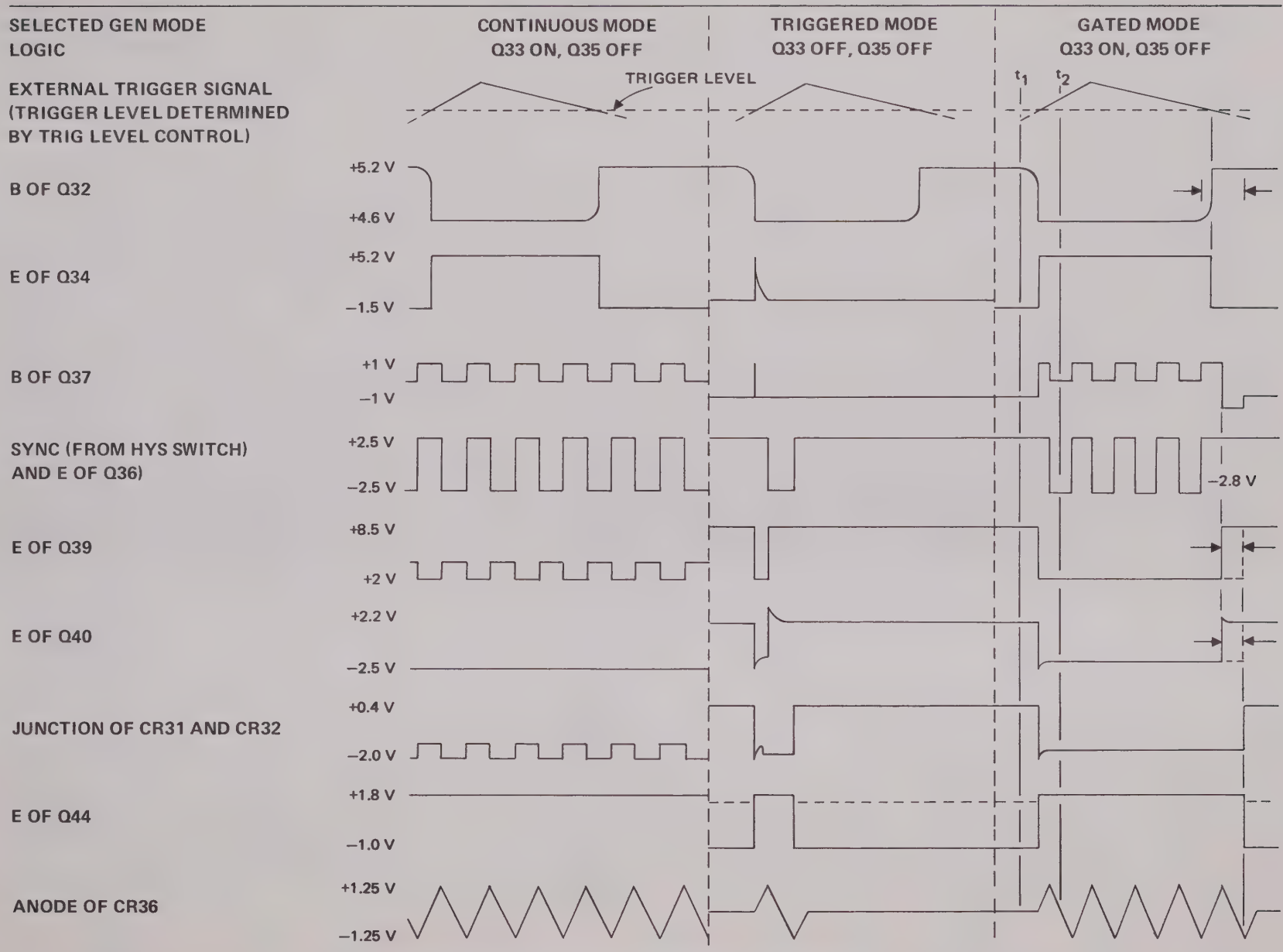


Figure 5-2. Typical Voltage and Waveforms for Trigger Circuit

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
D	**Trigger Amplifier Problem**		
D1	Set GEN MODE to GATED and TRIG LEVEL control fully ccw.	D2	
D2	Voltage at E of Q44 is about −0.7 volt (TRIG START/STOP at 0° CAL), +1.5 volts and generator is oscillating, if TRIG LEVEL is fully cw.	D2.1	D3
D2.1	Voltage at E of Q44 can be varied from −2 volts to +0.6 volt if TRIG START/STOP is set to VAR and its VARIABLE control is rotated.	D2.2	D3
D2.2	Trigger amplifier is operating normally.		
D3	Voltage across R229 is less than 1.5 volts.	D4	D3.1
D3.1	Baseline compensation circuit is malfunctioning; check for defective IC8 and its circuitry.		
D4	Zero voltage at junction of R223 and R237 (amplifier summing node).	D5	D4.1
D4.1	Check for defective Q41 - Q44. *Note: Voltage at E of Q42 is +8 volts, and E of Q43 is −8 volts. Q44 is a voltage follower.)* High frequency oscillation at E of Q44 indicates defective capacitors C82 - C87.		
D5	Check for defective CR31 - CR35.		
5.4.2	**VCG Amplifier and Current Generator Troubleshooting Procedure**		
E	**Current Generator Problem**		
E1	Set FREQ (Hz) to X 1K or more, SYMMETRY OFF, and FREQ VERNIER at CAL.	E2	
E2	Rotate the frequency dial from full cw to full ccw and observe voltage variation as described in Steps E3 thru E7.		
E3	Voltage at junction of R22 and R24 varies from 0 volt to about −5.7 volts.	E4	F
E4	Voltage at E of Q5 varies from about +14.5 volts to +6.7 volts.	E5	G
E5	There is no observable voltage (less than 1 μV) seen across R55.	E6	G4.1
E6	Voltage at E of Q6 varies from −15 volts to −9.3 volts.	E7	H
E7	There is no observable voltage seen across R56.	E8	H2.3
E8	Both current generators are operating properly.		
F	**VCG Amplifier Problem**		
F1	Troubleshooting hints: a. Pin 2 and pin 3 of IC1 is always zero volt. b. Under normal operating conditions, voltage at pin 6 is between 0 and −10 volts when dial is rotated from full cw to full ccw. c. Voltage at pin 6 will cut to half if X .001 Hz FREQ range is selected.	F2	
F2	If VCG amplifier works normally.	E4	
G	**Positive Current Generator Problem**		
G1	Voltage at pin 2 and pin 3 of IC3 is zero volt.	G2	G1.1
G1.1	Check for defective IC3 and Q1; voltage across R35 should be zero volt.		
G2	Voltage at pin 2 of IC5 varies from 0 to −5.7 volts when dial is rotated cw to ccw.	G3	H1.1

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
G3	Voltage at D of Q1 varies from about +14.5 volts to +6.7 volts when dial is rotated cw to ccw.		
G3.1	Check for defective R41, R40, C7, and SYMMETRY switch.		G.4
G4	Repeat Step E2, E4, and E5.	E2	G4.1
G4.1	Check for defective IC6, Q3, Q5, and the associated circuitry. *(Note: Check for correct power supply voltage and defective capacitor C8, C10, or C12.)*		
H	**Negative Current Generator Problem**		
H1	Voltage at S of Q2 varies from 0 volt to about −5.7 volts when dial is rotated cw to ccw.	H2	H1.1
H1.1	Check for defective IC5 and Q2.		
H2	Voltage at D of Q2 varies from −15 volts to −9.3 volts, and zero volt is across R37 when dial is rotated cw to ccw.	H3	H2.1
H2.1	Zero voltage at pin 2 of IC3.	H2.2	G
H2.2	Check for defective R40, R41, C7, and SYMMETRY switch.	H2.3	
H2.3	Check for defective IC7, Q4, Q6, and the associated circuitry. *(Note: Check for correct power supply voltage and defective capacitor C9, C11, or C13.)*		
H3	Repeat Steps E2, E6, and E7.	E2	H2.3
5.4.3	**Triangle Generator Troubleshooting**		
I	**Start/stop Switch and Diode Gate Problems**		
I1	A ±1.25 V triangle is seen at E of Q11 in CONT mode.	I1.1	I1.2
I1.1	Triangle generator is running; refer to Paragraph 5.3 for other problems.	5.3	
I1.2	Voltage at E of Q44 (trigger amplifier) is greater than +1.2 volts.	I1.4	I1.3
I1.3	Troubleshoot the trigger circuit.	5.4.1	
I1.4	CR36 is shorted.		I2
I2	Set dial to 3.0, FREQ (Hz) to X 1K, and SYMMETRY OFF.	I3	
I3	Both voltages across R163 and R164 are about 500 mV; voltages will decrease if dial is rotated cw.		I3.1
I3.1	Troubleshoot the current generator.	5.4.2	I4
I4	Voltage difference between G of Q9 and E of Q11 is less than 300 mV.	I5	J
I5	Voltage at E of Q11 is within ±1.25 volts.	I7	K
I6	Check for shorted C22, C64, or C65.		I7
I7	Check for defective Q23, Q24, C68, and the associated circuitry. *(Note: Q23 and Q24 are voltage followers, the voltages of which should be the same as C of Q14.)*		I8
I8	Voltage at C of Q14 is either +2.4 ±0.5 volt or −2.4 ±0.5 volt.		
I8.1	R124 is out of calibration.		K
I9	Check for defective CR14 - CR17. *(Note: None should have more than 900 mV forward voltage.)*		
J	**Triangle Amplifier No. 1 Problem**		
J1	6.4 volts ±0.6 volt across both CR6 and CR8.	J2	
J1.1	Defective CR6, CR8, C24 or C25.		

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
J2	Check for defective Q11 and Q12. *(Note: Q11 and Q12 are voltage followers.)*		
J3	Check for defective Q9 and Q10. *(Note: G to S voltage should be reversed bias. Voltage across R86 and R87 are the same.)*		J4
J4	Check for shorted C27.		
K	**Hysteresis Switch Problem**		
K1	Voltage at pins 2 and 8 of IC11 are about −2 volts.	K2	K1.1
K1.1	Voltage across R118 and R121 is less than 30 mV.	K1.2	K4.1
K1.2	Defective R119, R123, or R124.		
K2	Voltage at pins 3 and 9 of IC11 are about 0.7 volt below that at pins 2 and 8.	K3	K4.1
K3	Voltage at B of Q14 is no more than one volt less than that at B of Q15.	K3.1	K3.3
K3.1	Q14 is ON and Q15 is OFF (zero volt across R128 and 5 volts across R114).	K4	K3.2
K3.2	Check for defective Q14 and Q15.		
K3.3	Q14 is OFF and Q15 is ON (5 volts across R128 and zero volt across R114).	K4	K3.2
K4	Voltage at B of Q14 is 7.5 volts ±1 volt.	K5	K4.1
K5	Voltage at pin 7 of IC11 is within 0 and 200 mV.	K6	K4.1
K6	Voltage at E of Q11 is greater than +1.25 volts.	K8	K7
K7	Voltage at E of Q11 is less than −1.25 volts.	K9	I5
K8	Voltage at pin 4 of IC11 is greater than zero volt.	K3.3	K8.1
K8.1	Check for defective R101, R109, R110, R111, CR10, and C35 - C38.		
K9	Voltage at pin 1 of IC11 is less than zero volt.	K3.1	K9.1
K9.1	Check for defective R100, R108, R107, R106, CR9, and C31 - C34.		
5.4.4	**Troubleshooting the Capacitance Multiplier Circuit**		
L	**Capacitance Multiplier Problem**		
L1	Set FREQ (Hz) to X 10 and check for correct waveform as shown in Figure 5-3.	L1.1	L2
L1.1	Capacitance multiplier is running. Refer to Paragraph 5.3 for other capacitance multiplier related problems.	5.3	
L2	Check the multiplier statically by setting FREQ (Hz) to X 100. *(Note: The multiplier is disconnected from the main generator and therefore the circuit is under a dc bias condition.)*	L3	
L3	Voltage at wiper of SW1-C is zero volt.	L4	L3.1
L3.1	Check for defective switch wafer SW1-C and related circuitry.		
L4	Voltage at pin 6 of IC9 is 0 ±200 mV.	L5	L4.1
L4.1	Check for defective IC9, C17, and R64 - R68.		
L5	Voltage at pin 6 of IC10 is zero volt (or adjustable to zero with R74).	L6	L5.1
L5.1	Check for defective IC10, Q8, and C21. *(Note: Voltages at S of Q8A and Q8B are equal and more positive than voltages at G's under normal operating condition.)*		
L6	Short wiper of SW1-C to ground with a jumper wire. Switch FREQ (Hz) control between X 10 Hz and X .001 Hz and observe that voltage at wiper of SW1-B changes no more than 10 mV.	L1	L6.1

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
L6.1	Defective Q8, or Q8 has IDSS less than 1 mA and should be replaced. *(Note: Defective Q8 will cause frequency accuracy and time symmetry problem at low frequency, especially at X .001 Hz range.)*		

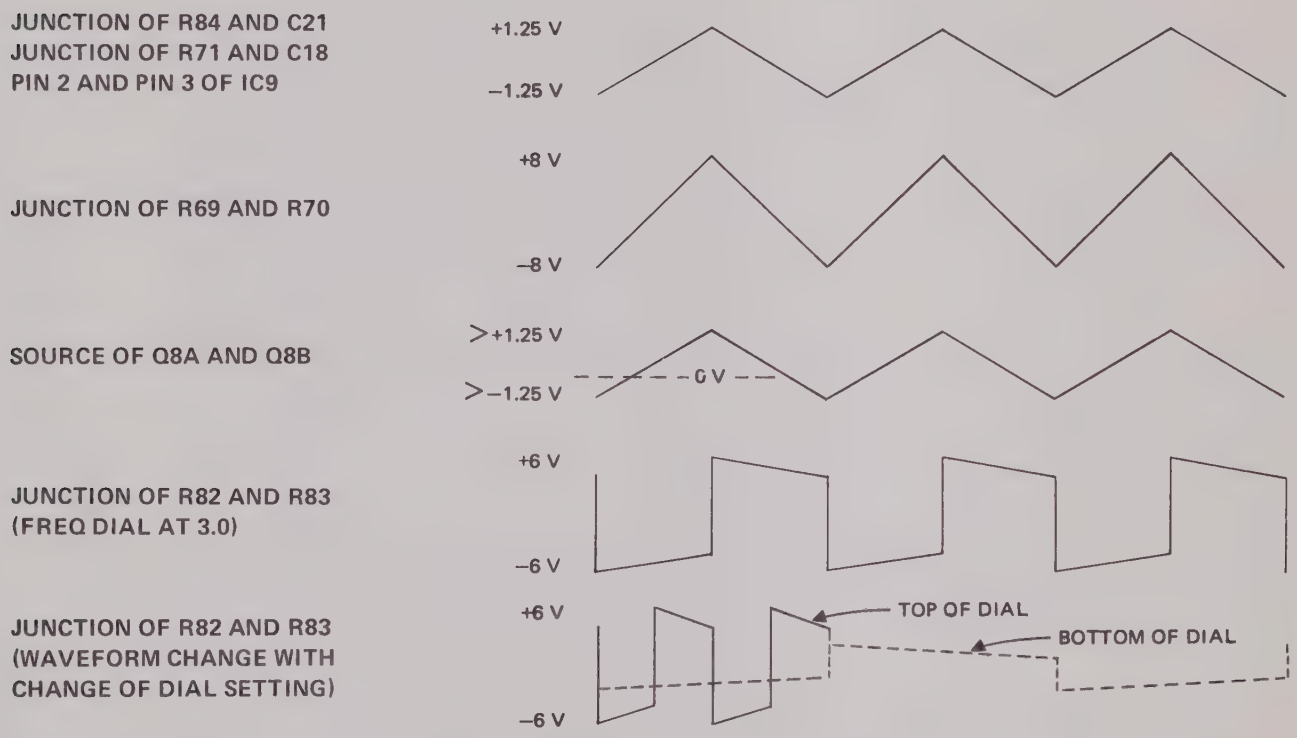


Figure 5-3. Key Waveforms of Capacitance Multiplier

5.4.5 Amplifier Troubleshooting Hints

1. If the output of an amplifier is saturated at a portion of the input waveform or all the time, the simplest method is to follow Paragraph 5.2 to locate a defective semiconductor or capacitor.

2. If high frequency oscillation is seen at the output of an amplifier, usually it is due to a defective capacitor. Sometimes, a defective capacitor can be located by touching the PC circuit traces to find the most signal sensitive area.

3. Look for burnt or overheated components.

4. Slow frequency response and rise/fall times are usually due to a defective capacitor. Use a good capacitor to jumper across each of the capacitors in the amplifier to locate the open-circuit capacitor.

5.4.6 Triangle Amplifier No. 2 Troubleshooting Hints

1. The triangle amplifier no. 2 circuit is a unity gain amplifier. Voltage at B of Q17 is the same as at the B of 19. A ±1.25 V p-p triangle signal is seen at these points when the generator is running.

2. Voltage at E of Q18 is about +11 volts.

3. Voltage at E of Q20 is about –7.5 volts.

4. A 2.5 V p-p triangle, with +5.5 volt offset should be seen at E of Q21 when the generator is running.

5. R142 adjusts the dc offset of the amplifier.

5.4.7 Preamplifier Troubleshooting Hints

1. The preamplifier circuit is an inverting amplifier thru which the selected waveform passes before going to the output amplifier.

2. The output waveform at junction of R393 and R394 is about 5.3 V p-p.

3. Voltage at junction of C129 and C130 is zero volt (summing junction).

4. Voltages across R385 and R390 are equal, about 8 volts.

5. Q67, Q68, and Q69 are dc-bias elements for the amplifier.

6. C133 is switched in or out of the circuit, depending on the waveform selected, to optimize the frequency response.

7. Defective C128 causes overshoot and dipping of square wave corners.

5.4.8 Output Amplifier Troubleshooting Hints

1. Like the preamplifier, the output amplifier is also an inverting amplifier.

2. Junction of C109 and C111 is zero volt (summing junction).

3. Voltages across R305 and R313 are equal, about 8 volts.

4. Q54, Q55 and Q56 are dc-bias elements.

5. Q61 and Q62 compose the output current limiting stage. Normally the two transistors do not conduct unless the output loading current exceeds 140 mA.

6. If C105 is opened, the square wave corners will show excessive rounding.

7. Defective C107 causes overshoot and dipping of square wave corners.

8. Defective C109 - C115 will cause high frequency waveform roll-off or oscillation on the waveform.

5.4.9 To Locate Short Circuit Components

1. Check for normal impedance and/or loading current to determine if the source of short is in power supply or other circuit. Refer to Paragraph 5.4.10.

2. Short circuit component can be located by troubleshooting the malfunctioning circuit if the short circuit does not cause low power supply voltage or blowing fuse.

3. If power supply voltage is low but fuse is not blown immediately, look for overheated components, burnt parts, or discolored circuit board.

4. Inspect the circuit board carefully for any solder bridges.

5. Localize the short circuit to one or a pair of power supply circuits by impedance measurement; refer to Paragraph 5.4.10. Then disconnect power supply voltages to each part of the circuit by removing jumper or series resistor (usually 10Ω to 100Ω) along the power supply path until the short circuit area is isolated. Then locate the short in that area. Power supply transistors and bypass capacitors are the most frequently shorted components.

5.4.10 Loading Current and Impedance of Power Supply

Typical current and impedance of each power supply loading are provided as a reference in case symptoms of a short circuit are observed. Before making any measurement, set the generator controls as follows:

FREQ	X 1K
DIAL	3.0
SYMMETRY	OFF
WAVEFORM	∿
OUTPUT ATTEN (dB)	−10 dB (no load at 50Ω OUT)
OUTPUT VARIABLE	Manually cw
GEN MODE	GATED
DC OFFSET	OFF
TRIG START/STOP	0° CAL
SWEEP MODE	RAMP UP
SWEEP/STEP TIME	OFF

1. Loading current is measured by first unsoldering the power supply wire to the circuit board from the power supply connector so as to connect an ammeter in between.

2. Impedance is measured at the same point as above relative to the ground on the PC board, unless otherwise specified.

3. Unplug the connector between main board and sweep board for impedance measurement. Unplug the sweep board only when making current loading measurements on the main board.

Typical impedance across and loading current into each power supply are shown in the following table:

Main Circuit Board

POWER SUPPLY	IMPEDANCE	LOADING CURRENT
+15 volts	400	400 mA
−15 volts	600	380 mA
+24 volts	20K	50 mA
−24 volts	20K	45 mA
+ 5 volts		0
between ±15 volts	1K	—
between ±24 volts	25K	—

Sweep Board

POWER SUPPLY	IMPEDANCE	LOADING CURRENT
+15 volts	3K	85 mA
−15 volts	4.2K	70 mA
+15 volts	3K	110 mA
between ±15 volts	2.7K	—

Note: Impedance and current are accurate to within ±20% and will vary if panel controls are set differently.

5.4.11 Power Supply Troubleshooting Hints

1. Unplug the power supply connector from the main board if power supply voltage is out of regulation.
2. 60 cycle ripple on supply voltage may be due to wrong HI/LO switch selection. Check ac line voltage and select the proper switch setting accordingly.
3. Power supply voltages are interrelated. Malfunctioning +15 volt supply will cause the −15, ±24 volt supplies to be out of regulation. Malfunctioning ±24 volt supplies, however, will not affect the others.
4. Q3, Q7, Q12, and Q16 are current limiting transistors which do not conduct under normal operating conditions. Supply voltage will be zero if these transistors have a short circuit.
5. The power supply voltages being normal without a load and the voltage being low under a normal load indicate Q2, Q6, Q10 or Q14 as being an open circuit.
6. Fuse blown with the power supply being plugged in may be due to wire insulation being broken, shorted transformer, power transistor shorted to heat sink, defective CR1 to CR8, or shorted power supply bypass capacitor. Isolate the short by disconnecting each part of the circuit.

5.4.12 Troubleshooting Guide for Sweep Circuit

	SYMPTOM	CORRECTIVE PROCEDURES
1.	No sweep signal output at SWP OUT when selecting CONT SWP.	a. IC2 or the associated circuit is defective if ramp signal is seen at pin 10 of IC10. b. Ramp generator is not running; refer to Step M.
2.	Lost or distorted sweep signal at SWP OUT when STEP UP or RAMP UP is selected.	a. IC3 or the associated circuit is defective.
3.	Ramp waveform is not linear, and gets worse at 10 s and 100 s sweep.	a. Q11, Q13, Q14, C24 or C25 is defective (excessive leakage current).
4.	Ramp waveform is not linear; same nonlinear waveform at all frequencies.	a. Check for defective diodes CR15 - CR20.
5.	Positive peak voltage of ramp is less than 5 volts.	a. If peak voltage varies with frequency, defective C31 or CR25. b. If voltage is low at all frequencies, defective CR28, R68, R70, R71, or CR22.
6.	Reference voltage of ramp does not reach zero.	a. If peak voltage varies with frequency, defective C30, CR23 or CR24. b. If voltage is high at all frequencies, defective CR29, R67, CR21, R69, R73 or R72.

	SYMPTOM	CORRECTIVE PROCEDURES
7.	High frequency oscillation on the ramp waveform.	a. Check for defective capacitors associated with IC2, IC3 and IC10.
8.	No step signal output in any mode; ramp signal output is normal.	a. Q18 is defective if clock pulse is not seen at CLOCK input of the digital circuit (at R31). b. D/A amplifier is defective; refer to Step R. c. Follow Step S to check for defective components in the digital circuit.
9.	Signal at SWP OUT is not stepping in TRIG SWP, SWP HOLD, or SINGLE STEP mode when triggered.	a. If the main generator is not operating in TRIG and GATED modes, problem is in the main generator trigger circuit. b. If there is no ramp output when RAMP UP is selected and the generator is triggered, problem is in the ramp control logic circuit.

5.4.13 Troubleshooting of Sweep Circuit

NOTE

The following circuits are located on the sweep board.

STEP	PROCEDURE	IF TRUE GO TO	IF FALSE GO TO
M	**Quick Troubleshooting Procedure for Ramp Generator**		
M1	Set GEN MODE to CONT SWP, SWEEP/STEP TIME to any position other than OFF.	M1.1	
M1.1	A ramp signal (0 to +5 volt sawtooth) is seen at junction of R62 and R63.	M1.2	M2
M1.2	Ramp generator is running normally; refer to Paragraph 5.4.12 for other sweep problems.		
M2	Set SWEEP/STEP TIME to OFF.	M2.1	
M2.1	Voltage at G of Q14A is 0 volt.	M2.3	M2.2
M2.2	Defective switch wafer SW9-B.		
M2.3	Voltage at junction of R62 and R63 is 0 ±30 mV.	M3	M2.4
M2.4	Ramp generator amplifier is malfunctioning; refer to Step N.	N	
M3	Voltage at pin 7 and pin 10 of IC11 is 0 to –50 mV dc.	M4	M3.1
M3.1	Voltage at pin 7 of IC11 is greater than zero volt.	M3.2	M3.3
M3.2	Check for defective Q20, SW8-A, and the associated circuitry.		
M3.3	If voltage at pin 7 is below –50 mV, IC11 is defective.		
M4	Voltage at C of Q19 is greater than zero volt.	M5	M4.1
M4.1	Check for defective SW5-A, C35, C33, and the associated circuit components.		
M5	Generator control logic is normal. Follow Step Q to check out the hysteresis switch circuit.	Q	
N	**Ramp Generator Amplifier Troubleshooting**		
N1	Set SWEEP/STEP TIME to OFF.	N2	
N2	Voltage at G of Q14A should be zero volt.	N3	N2.1
N2.1	Check for defective SW9-B.		
N3	Voltage at junction of R62 and R63 is 0 ±50 mV.	N3.1	N4
N3.1	Voltages at S of Q14A and Q14B are greater than zero volt.	N3.3	N3.2
N3.2	Q14 is defective.		

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
N3.3	The ramp generator amplifier is operating normally.		
N4	Check for defective IC10; refer to Paragraph 5.2.3.		N4.1
N4.1	If oscillation is seen, C27 is defective.		N4.2
N4.2	Check for defective diodes, CR15 - CR18; refer to Paragraph 5.2.2.		N3.1
P	**SWEEP/STEP TIME Control Circuit Troubleshooting (when ramp generator is not running at CONT SWP)**		
P1	Voltage at E of Q7 is +5 volts ±0.5 volt.	P2	P1.1
P1.1	Q7 is defective.		P2
P2	Voltage across CR12 is 6.4 ±0.5 volt.	P3	P2.1
P2.1	Check for defective CR12 and C21.		
P3	Voltage at E of Q10 is +5.5 volts ±1 volt.	P4	P3.1
P3.1	Defective Q10.		
P4	Set SWEEP/STEP TIME to 100/10 μs, and VARIABLE fully cw.	P5	
P5	Voltage at G of Q14A is less than zero volt if voltage at B of Q9 is less than −0.5 volt; or voltage at G of Q14A is greater than +5 volts if voltage at B of Q9 is greater than +0.5 volt.	P6	P5.1
P5.1	C24 is defective (shorted) if voltage at G of Q14A is zero.		P5.2
P5.2	Q8 or Q9 is defective if voltage across R54 is not zero volt when voltage at B of Q9 is greater than +0.5 volt; or if voltage across R54 is not greater than 5 volts when voltage at B of Q9 is less than 0.5 volt.		P5.3
P5.3	C22 is defective (shorted) if voltage at B of Q9 is zero.		P5.4
P5.4	Voltage at B of Q11 should be more positive, or at least 0.9 volt more negative than its collector, or Q11 is defective.		P5.5
P5.5	Q12 is defective if voltage at C of Q12 is greater than 400 mV.		
P6	SWEEP/STEP TIME control circuit is functioning, unless ramp waveforms are not linear due to excess leakage current of Q11, Q13, Q14A, C24 or C25.		
Q	**Ramp Generator Hysteresis Switch Troubleshooting (when ramp generator is not running in CONT SWP)**		
Q1	Set GEN MODE to CONT SWP.	Q2	
Q2	Voltage at pin 7 of IC11 is zero to −50 mV.	Q3	Q2.1
Q2.1	Voltage at junction of CR28 and CR30 is equal to or less than zero volt.	Q2.2	Q2.3
Q2.2	IC11 is defective.		
Q2.3	Defective switch wafer SW8-A or SW5-A, or PC circuit (voltage at R98 should be zero volt in CONT SWP mode).		
Q3	Voltage at pin 10 of IC11 is zero to −50 mV.	Q4	Q3.1
Q3.1	Voltage is positive at pin 10.	Q3.2	Q3.3
Q3.2	CR29 is defective.		
Q3.3	Voltage at junction of CR29 and CR31 is positive.	Q2.2	
Q3.4	Defective C35, switch wafer SW5-A or PC circuit (voltage at R99 is +15 volts in CONT SWP mode).		
Q4	Voltage at pin 10 of IC10 is less than zero.	Q4.1	Q6
Q4.1	Voltage at E of Q15 is greater than +0.5 volt.	Q4.2	Q4.3
Q4.2	Problem is in the SWEEP/TIME control circuit.	P1	
Q4.3	Voltage at pin 1 of IC11 is less than zero volt.	Q5	Q4.4
Q4.4	R72 is out of calibration.		Q4.5
Q4.5	Check for defective CR21.		

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
Q5	Check for defective Q15 and Q18. (Both are voltage followers.)		Q5.1
Q5.1	Zero volt across R86 (Q17 OFF) if voltage at E of Q16 is more negative than voltage at E of Q17; otherwise, voltage across R76 is zero (Q16 OFF).	Q5.3	Q5.2
Q5.2	Q16 or Q17 is defective.		
Q5.3	IC11 or the associated circuit is defective. See Figure 5-4 for correct voltage levels.		
Q6	Voltage at pin 10 of IC10 is greater than +5 volts.	Q6.2	Q6.1
Q6.1	Problem is in the ramp generator amplifier or sweep/time control circuit.	N1	
Q6.2	Voltage at pin 4 of IC11 is greater than zero.	Q7	Q6.3
Q6.3	R70 is not calibrated.		Q6.4
Q6.4	CR22 is defective.		Q5.5
Q7	Voltage at E of Q15 is less than −0.5 volt.	Q4.2	Q5

5.4.14 10-Step D/A Converter Troubleshooting Hints

NOTE

The step control logic timing diagram is shown in Figure 5-4.

1. Voltage at pins 2 and 3 are always +2 volts, or IC1 is malfunctioning.

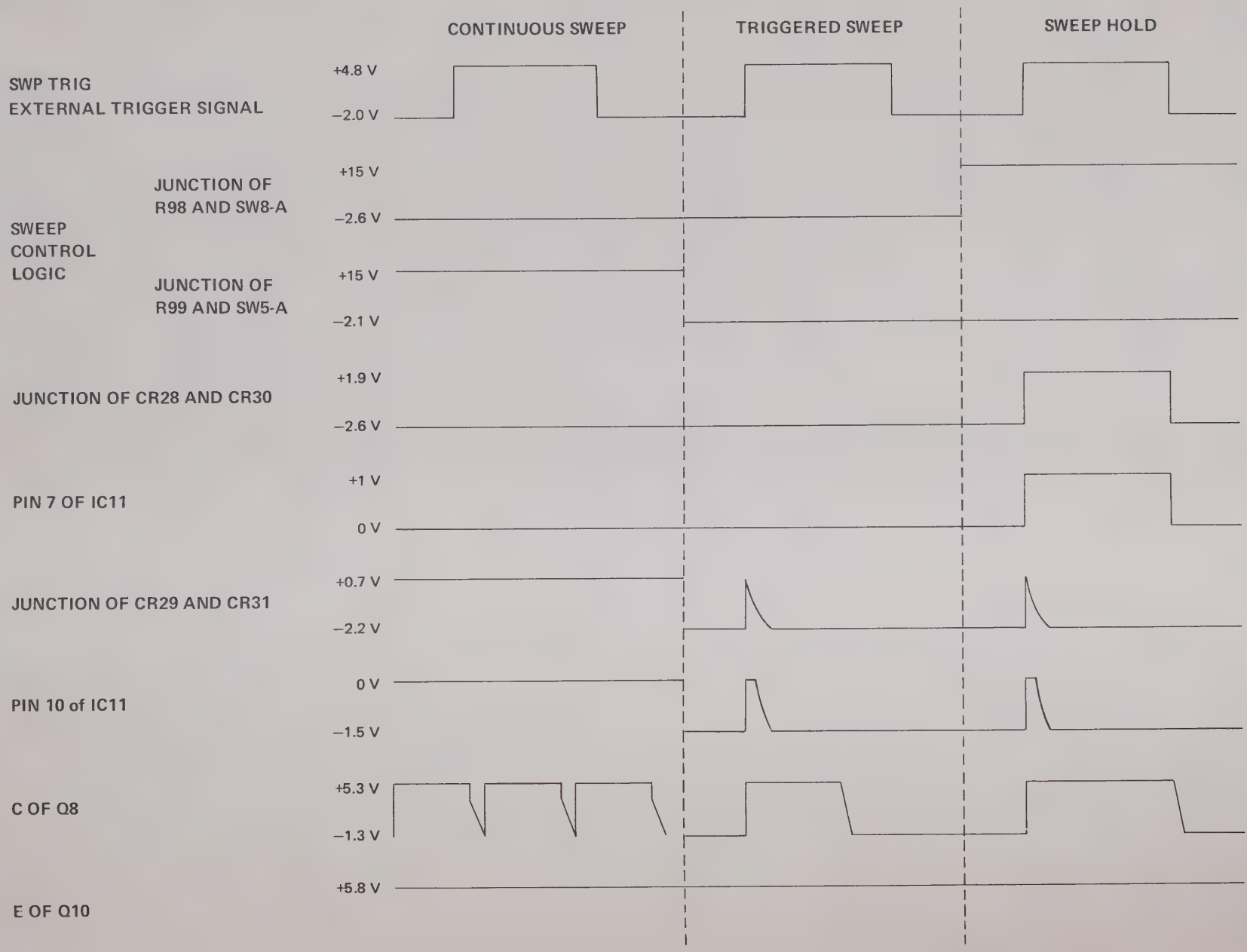
2. Resistors R3 - R7, R9 and R10 are connected in such a way that the current ratio thru the current switches (CR1 - CR11 and CR35) are 4:4:2:1. Staircase is generated by switching the currents in different combinations thru Q1 into the summing junction of IC2 (pin 4).

3. Set GEN MODE to TRIG SWP and STEP UP; without triggering the generator, voltages at pins 11, 12, 13 and 14 of IC4 should be less than +0.8 volt or the problem is in the logic circuit; refer to Paragraph 5.4.15.

4. If some of the steps are missing in the step waveform output, refer to Step R24 in Paragraph 5.4.16.

5.4.15 Digital Step Generator Troubleshooting Guide

	SYMPTOM	CORRECTIVE PROCEDURE REFERENCE
1.	Generator will not step in any mode.	R1
2.	Generator will not run in TRIG SWP, SWP HOLD or SINGLE STEP.	R8
3.	Generator runs continuously in TRIG SWP, SWP HOLD or SINGLE STEP.	R9
4.	Staircase will not hold in the SWP HOLD mode.	R12
5.	Staircase has the wrong number of steps.	R19
6.	Generator takes a single step in TRIG SWP or SWP HOLD rather than 10 steps.	R9
7.	Staircase has the correct number of steps, but the wrong levels.	R24


CONTINUOUS SWEEP
TRIGGERED SWEEP
SWEEP HOLD
SWP TRIG
EXTERNAL TRIGGER SIGNAL
+4.8 V
−2.0 V
SWEEP
CONTROL
LOGIC
JUNCTION OF
R98 AND SW8-A
+15 V
−2.6 V
JUNCTION OF
R99 AND SW5-A
+15 V
−2.1 V
JUNCTION OF CR28 AND CR30
+1.9 V
−2.6 V
PIN 7 OF IC11
+1 V
0 V
JUNCTION OF CR29 AND CR31
+0.7 V
−2.2 V
PIN 10 of IC11
0 V
−1.5 V
C OF Q8
+5.3 V
−1.3 V
E OF Q10
+5.8 V

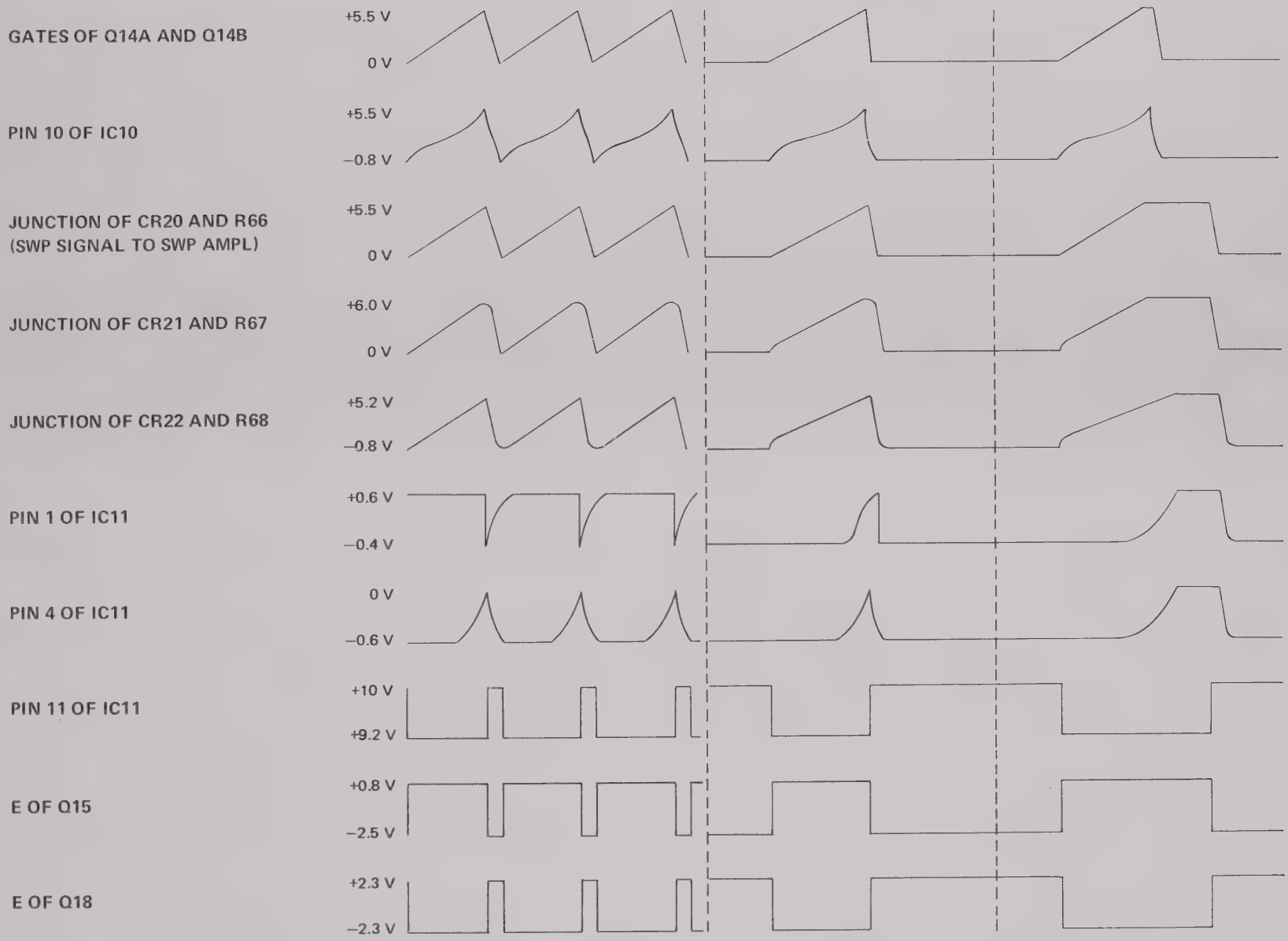


Figure 5-4. Sweep/Step Control and Ramp Generator Timing Diagram

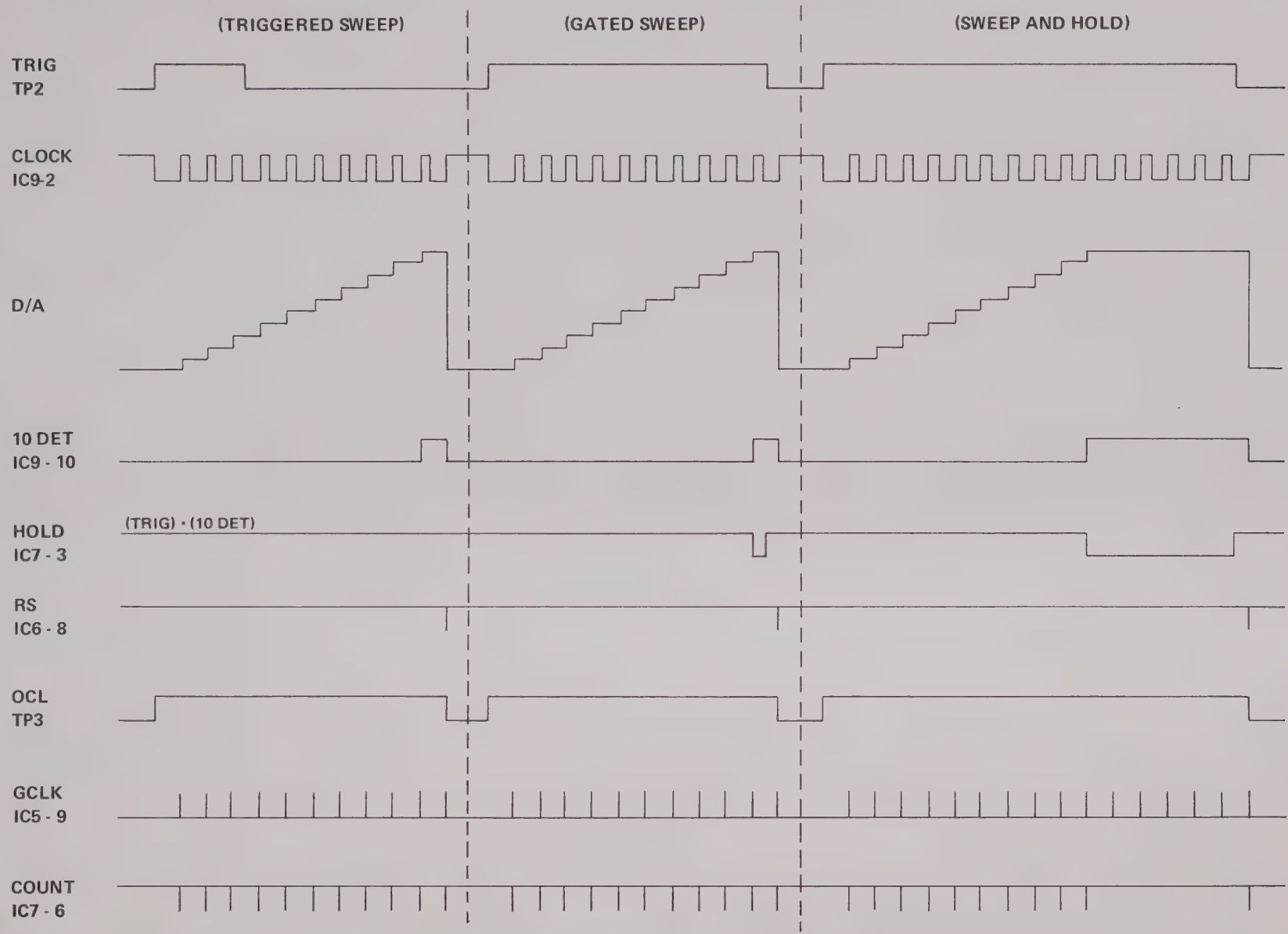


Figure 5-5. Step Control Logic Timing Diagram

5.4.16 Troubleshooting the Digital Step Generator

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
R	**Digital Step Generator Problem**		
R1	Place generator in STEP UP, CONT SWP with SWEEP/STEP TIME at 100 μs. Clock pulses should appear at TP1.	R2	R7
R2	Pulses at IC4 pin 2?	R3	R4
R3	IC4 defective.		
R4	Pin 4 of IC7 high?	R5	R6
R5	IC5 or IC9 defective.		
R6	IC8 or IC9 defective.		
R7	Troubleshoot the analog sweep generator circuit.		
R8	Troubleshoot the analog sweep generator circuit or the trigger amplifier circuit.		
R9	Place generator in TRIG SWP, STEP UP, with SWEEP/STEP TIME at 10 μs. Apply a 10 kHz ⊓⊔ to the TRIG IN connector. Pulses should appear at IC5 pin 5.	R10	R11
R10	IC7 or Q4 defective.		
R11	IC5 or IC9 defective.		
R12	Place generator in SWP HOLD, STEP UP, with SWEEP/STEP TIME at 10 μs. Apply a 2.5 kHz ⊓⊔ to the TRIG IN connector. IC6 pin 6 should pulse low when staircase attains its maximum level.	R13	R14
R13	IC9 pin 12 should be a TTL duplicate of the TRIG IN connector.	R15	R16
R14	IC6 or IC8 defective.		
R15	Is IC7 pin 1 high?	R17	R18
R16	Q5 or IC9 defective.		
R17	IC9 or IC7 defective.		
R18	IC8 defective.		
R19	Place generator in CONT SWP, STEP UP, with SWEEP/STEP TIME at 10 μs. Does IC6 pin 8 pulse low before counter state 11 (BCD)?	R20	R21
R20	IC6 or IC8 defective.		
R21	Does IC6 pin 8 pulse low at counter state 11 (BCD)?	R22	R23
R22	IC4 defective.		
R23	IC6 or IC8 defective.		
R24	IC4 or the D/A converter defective.		

SECTION 6
PARTS LISTS AND SCHEMATIC DIAGRAMS

6.1 DRAWINGS

Assembly drawings are positioned adjacent to the schematics. Additional voltage or waveform information, beyond that given in the circuit description, may be shown on the schematic diagrams, at test points and key locations throughout the instrument.

6.2 ADDENDA

Under Wavetek's product improvement program, the latest electronic designs and circuits are incorporated into each Wavetek instrument as quickly as development and testing permit. Because of the time needed to compose and print instruction manuals, it is not always possible to include the most recent changes in the initial printing. Whenever this occurs, addendum pages are prepared to summarize the changes made and are inserted immediately inside the rear cover. If no such pages exist, the manual is correct as printed.

6.3 ORDERING PARTS

When ordering spare parts, please specify part number, circuit reference, board, serial number of unit, and if applicable, the function performed.

6.4 DRAWINGS

The following assembly drawings (with parts lists) and schematics are in the arrangement shown below:

Chassis	Assembly Drawing and Parts List	164-000	Sheets 1-3
	Schematic	164-200	
Main Board	Schematic	0103-00-0119	Sheets 1-4
	Assembly Drawing	0101-00-0119	Sheets 1, 2
	Parts List	1100-00-0119	Sheets 1-6
Sweep Board	Assembly Drawing and Parts List	164-011	Sheets 1, 2
	Schematic	164-211	Sheets 1, 2
Rear Panel	Assembly Drawing and Parts List	162-001	
Power Supply	Assembly Drawing and Parts List	147-030	Sheets 1-3
	Schematic	147-230	

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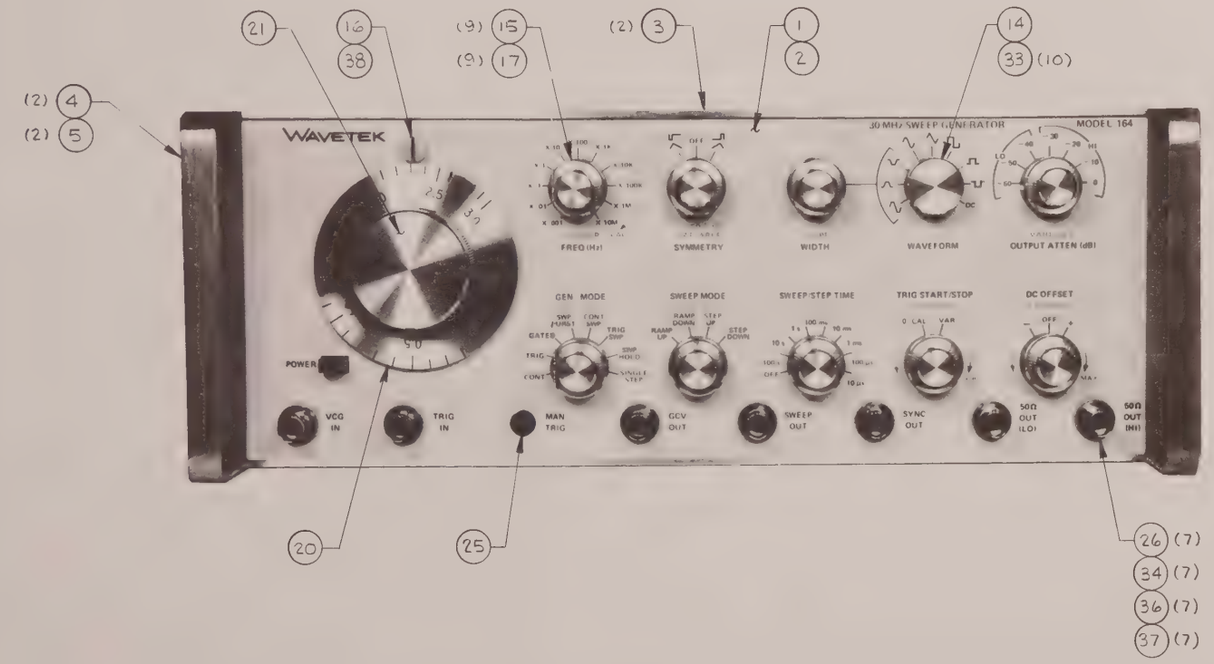

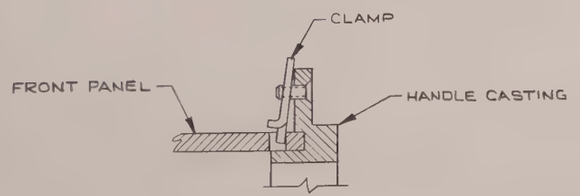

NOTE: BEFORE CLAMPING HANDLE CASTING IN PLACE, TRIM (TOP & BOTTOM) MUST BE IN PLACE

HANDLE DETAILS

PARTS LIST					
LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	SUB PANEL	WAVETEK	23338	C162-301	1
2	FRONT PANEL			C164-300	1
3	PANEL TRIM			B147-018	2
4	HANDLE			C141 364	2
5	HANDLE TRIM			B147 345	2
6	SIDE PLATE			B147 378	2
7	SUPPORT BAR			B147-347	1
8	CLAMP			A147-316	4
9	POWER SUPPLY ASSY.			D147-030	1
10	MAIN BOARD			D164-015	1
11	SWEEP BOARD			D164 011	1
12	COVER ASSY			C147-024	
13					
14	KNOB			B130-314	1
15	KNOB, COAX			B130-309	9
16	LENS			A141-317	1
17	KNOB, SMALL			B130-354	9
18	POWER SWITCH ROD			B147-382	1
19	POTENTIOMETER			A131-R1A	1
20	DIAL			B130-333	1
21	DIAL KNOB			B130-308	1
22					
23					
24	POWER CORD	BELDEN	16428	17250-B	1
25	SWITCH (MOMENTARY)	C & K	09353	7108 PDCN	1
26	BNC CONNECTOR	KINGS	91836	KC 7946	7
27	RESISTOR, M.F. 1/8W 1% 56.2Ω	CORNING	16299	RN55D	2
28	RESISTOR, M.F. 1/8W 1% 825Ω			RN55D	1
29	U-NUT	TINNERMAN		CB681-832-24	4
30	CHASSIS BLOCK	USECO	88245	1591B-11	3
31	SCREW, PHD., BLK OX., 8/32 X 5/8"	COMMERCIAL		8/32 X 5/8	4
32	TERMINAL	USECO	88245	1401A-9	1
33	BUSHING	THOMPSON	96881	4L2FF	10
34	WASHER (SHOULDER)	H.H. SMITH	83330	2668	7
35	WASHER (SHOULDER)			2661	2
36	WASHER (NYLON)			2264-N-385	7
37	SOLDER LUG			1497	7
38	RETAINER	WALDES	79136	5305-31	1
39	SPRING	WAVETEK		B147-383	1
40	BRACKET, ROD			B162-310	1
41	BRACKET, CONN.			B162-311	1

REV	I.N.	BY	DATE	APP
B	ECN #823	RD	9/18/70	
C	ECN 1074	RD	9/24/70	
D	ECN 1113	RD	9/20/70	
E	ECN 1052	RD	9/72	
F	ECN 1138	RD	9/1972	
G	ECN 1115	RD	9/1972	
H	ECN 1160	RD	12/4/72	
J	ECN 1174	RD	1/73	

2. * INDICATES ITEMS NOT SHOWN.

1. FOR CHASSIS WIRING SEE CHASSIS SCHEMATIC D164-200.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES | DRAWN B. REDMAN | DATE 3-5-70

MATERIAL | PROJ ENGR | RELEASE APPROV

FINISH WAVETEK PROCESS | TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES ±1 XX .030 | DO NOT SCALE DWG | SCALE NONE

WAVETEK SAN DIEGO, CALIFORNIA

TITLE ASSEMBLY, CHASSIS

MODEL NO 164 | DWG NO D164-000 | REV J

CODE IDENT 23338 | SHEET 1 OF 3

D164-000 1

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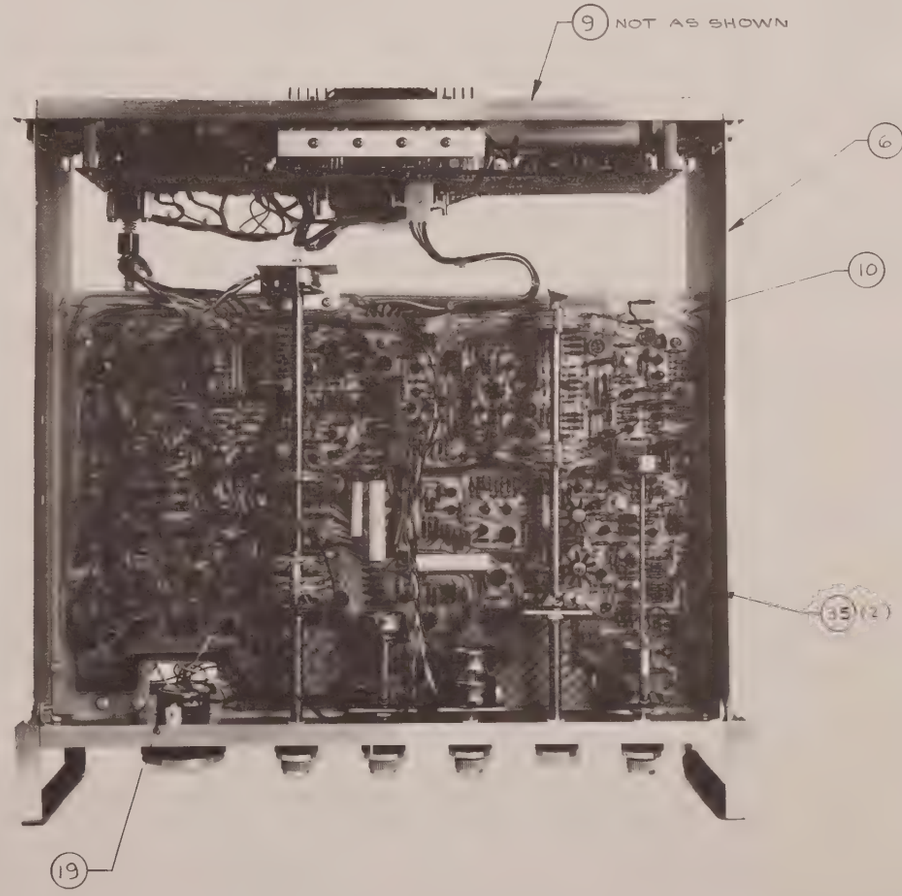
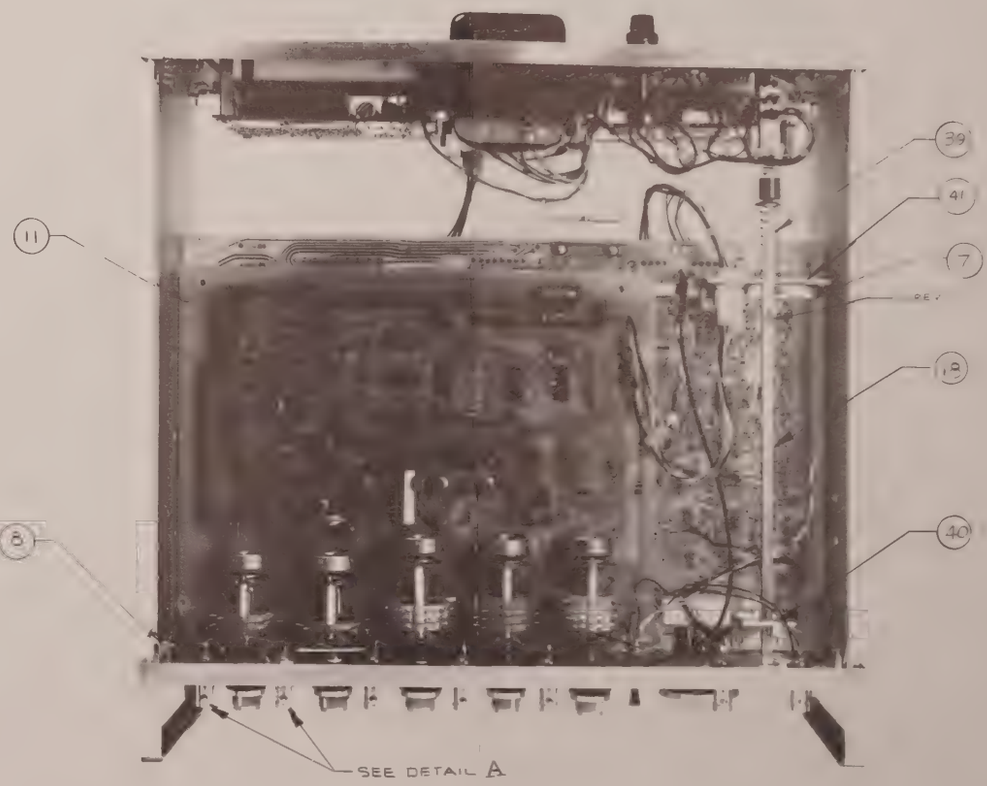
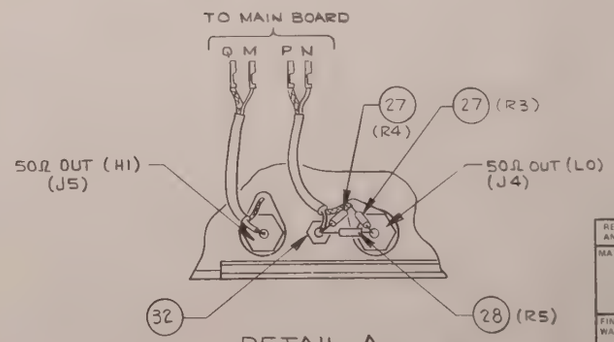
REV	ECN	BY	DATE	APP







DETAIL A
CONNECTOR HOOK-UP

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MATERIAL	PROJ ENGR		TITLE ASSEMBLY, CHASSIS
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES ±1 XX .030		
	DO NOT SCALE DWG	MODEL NO 164	DWG NO D164-000 REV J
	SCALE NONE	JOB NO 23338	SHEET 2 OF 3

D164-000 1

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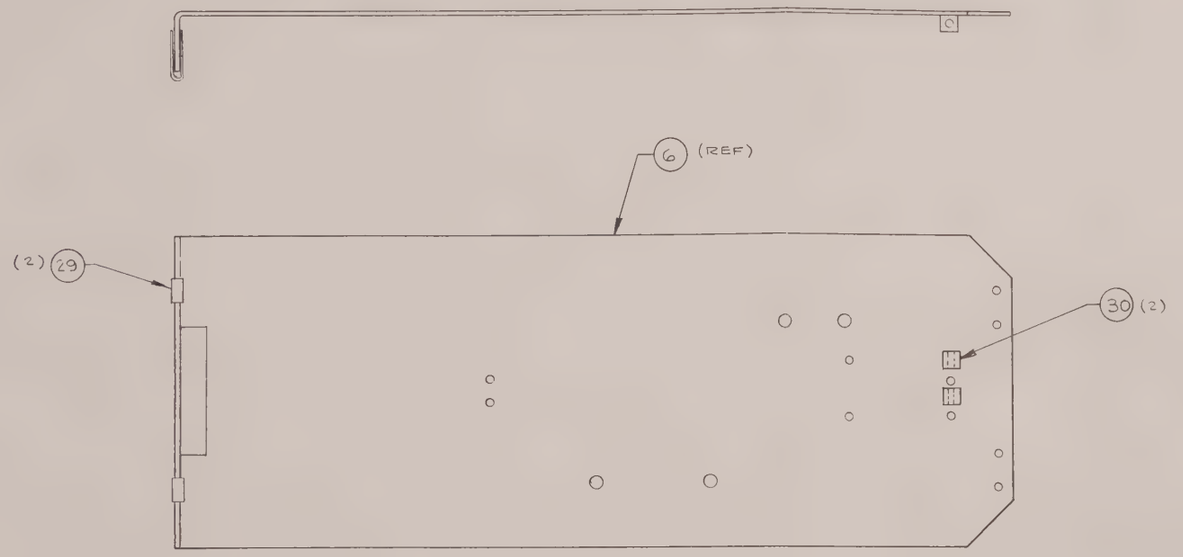
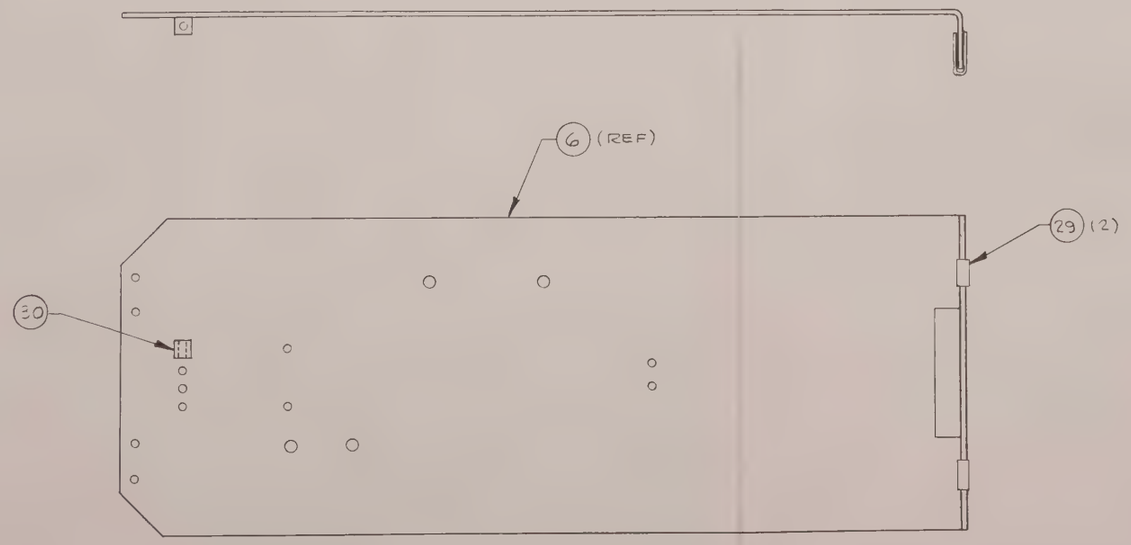
REV	ECN	BY	DATE	APP



SIDE PLATE
(RIGHT HAND)



SIDE PLATE
(LEFT HAND)

INSERT INSTALLATION DETAIL

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3-4-74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE ASSEMBLY, CHASSIS
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		
	DO NOT SCALE DWG		MODEL NO 164 / DWG NO D164-000 / REV J
	SCALE FULL		CODE IDENT 23338 / SHEET 3 OF 3

D164-000 J

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REV	ECN	BY	DATE	APP

POWER I1

FREQ CONTROL R1

WIDTH R194A

SLOPE R194B

50Ω OUT (HI) J5

50Ω OUT (LO) J4

R3 56.2Ω

R4 56.2Ω

R5 825Ω

R S F G H AG AB AH Z AA Q M P N

SYNC OUT J3

GCV OUT J6

BLK

MAN TRIG (MOMENTARY) SW10

TRIG IN J2

VCG IN J1

U T J E C D A B K L

MAIN BOARD
D164-015
SCHEMATIC
D164-215

P2 J9

1A 2A 3A 4A 5A 6A 7A 8A 9A Y

J8 1 2 3 4 5 6 7 8 9

P1 1 2 3 4 5 6 7 8 9

1 2 3 4 5 6 7 8 9 A

SWEEP OUT J7

B C

SWEEP BOARD
D164-011
SCHEMATIC
D164-211

HI/LO SW1

115/230V SW2 1.5V

POWER SW3

P3

F1

115V ½ AMP SB
230V ¼ AMP SB

POWER SUPPLY BD
D147-030
SCHEMATIC
D147-230

14 18 13 10 15 9 12 16 11 17

GRN W/BRN W/GRY VIO GRY W/GRN GRN BLU W/BLU BLU RED W/RED RED W/BLK BRN BLK

T1
B147-500

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 2-1374	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJENG Kwok C. Fu 4/1374	RELEASE APPROV	TITLE SCHEMATIC - CHASSIS
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030		
	DO NOT SCALE DWG	MODEL NO 164	DWG NO. D164-200 REV
	SCALE —	CODE IDENT 23338	SHEET 1 OF 1

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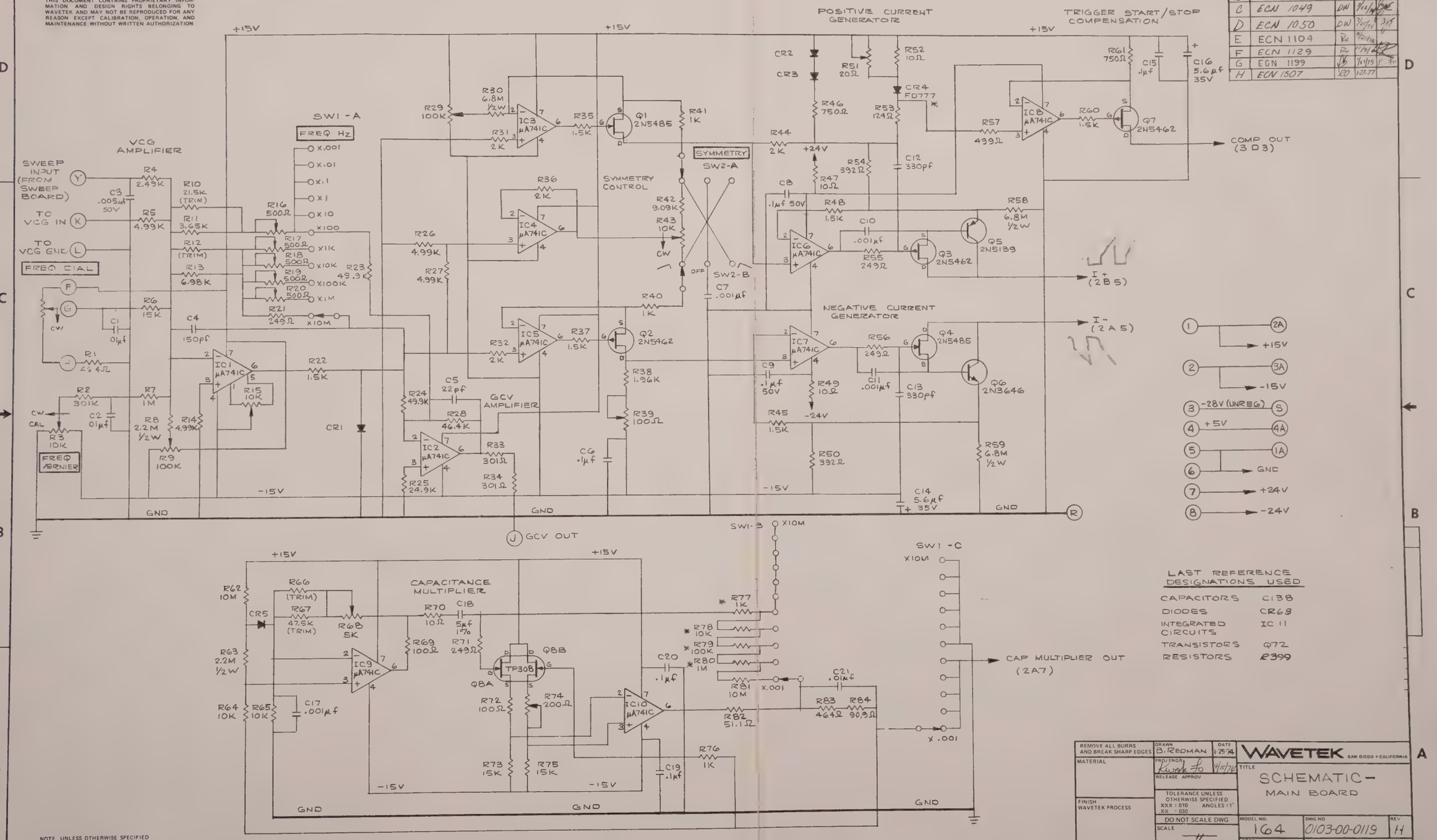
REV	ECN	BY	DATE	APP
B	ECN 980	DN	7/16/74	CK
C	ECN 1049	DN	9/24/74	CK
D	ECN 1050	DN	7/17/74	JS
E	ECN 1104	RO	9/20/74	
F	ECN 1129	RO	11/8/74	
G	ECN 1199	JB	4/3/75	
H	ECN 1507	RO	4-22-77	

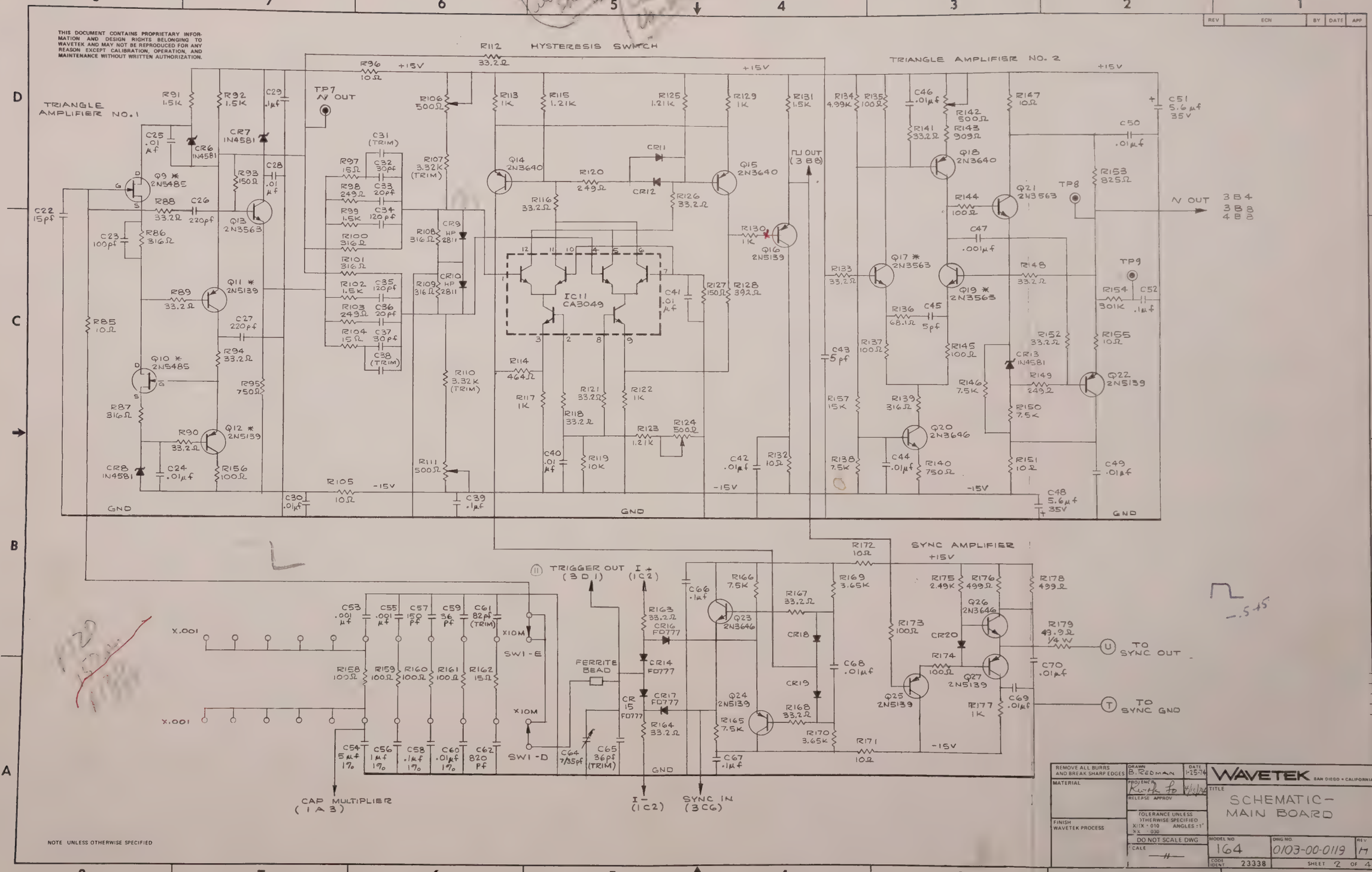


LAST REFERENCE DESIGNATIONS USED

CAPACITORS	C138
DIODES	CR68
INTEGRATED CIRCUITS	IC 11
TRANSISTORS	Q72
RESISTORS	R399

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 1-25-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE SCHEMATIC – MAIN BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030		
	DO NOT SCALE DWG		MODEL NO. 164
	SCALE —		DWG NO 0103-00-0119 REV H
			CODE IDENT 23338 SHEET 1 OF 4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REV ECN BY DATE APP
R112 HYSTERESIS SWITCH
TRIANGLE AMPLIFIER NO. 2
TRIANGLE AMPLIFIER NO. 1
SYNC AMPLIFIER
IC11 CA3049
TP7 N OUT
TP8
TP9
N OUT
TRIGGER OUT (3D1)
I+ (1C2)
I− (1C2)
SYNC IN (3C6)
CAP MULTIPLIER (1A3)
TO SYNC OUT
TO SYNC GND
FERRITE BEAD
SW1-E
SW1-D
X.001
X10M
+15V
-15V
GND
NOTE UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. TEDMAN
DATE 1-25-74
PROJENG
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XIX ± .010 ANGLES ± 1° .XX ± .030
DO NOT SCALE DWG
SCALE
WAVETEK SAN DIEGO • CALIFORNIA
TITLE
SCHEMATIC — MAIN BOARD
MODEL NO. 164
DWG NO. 0103-00-0119
REV H
CODE IDENT. 23338
SHEET 2 OF 4
0103-00-0119

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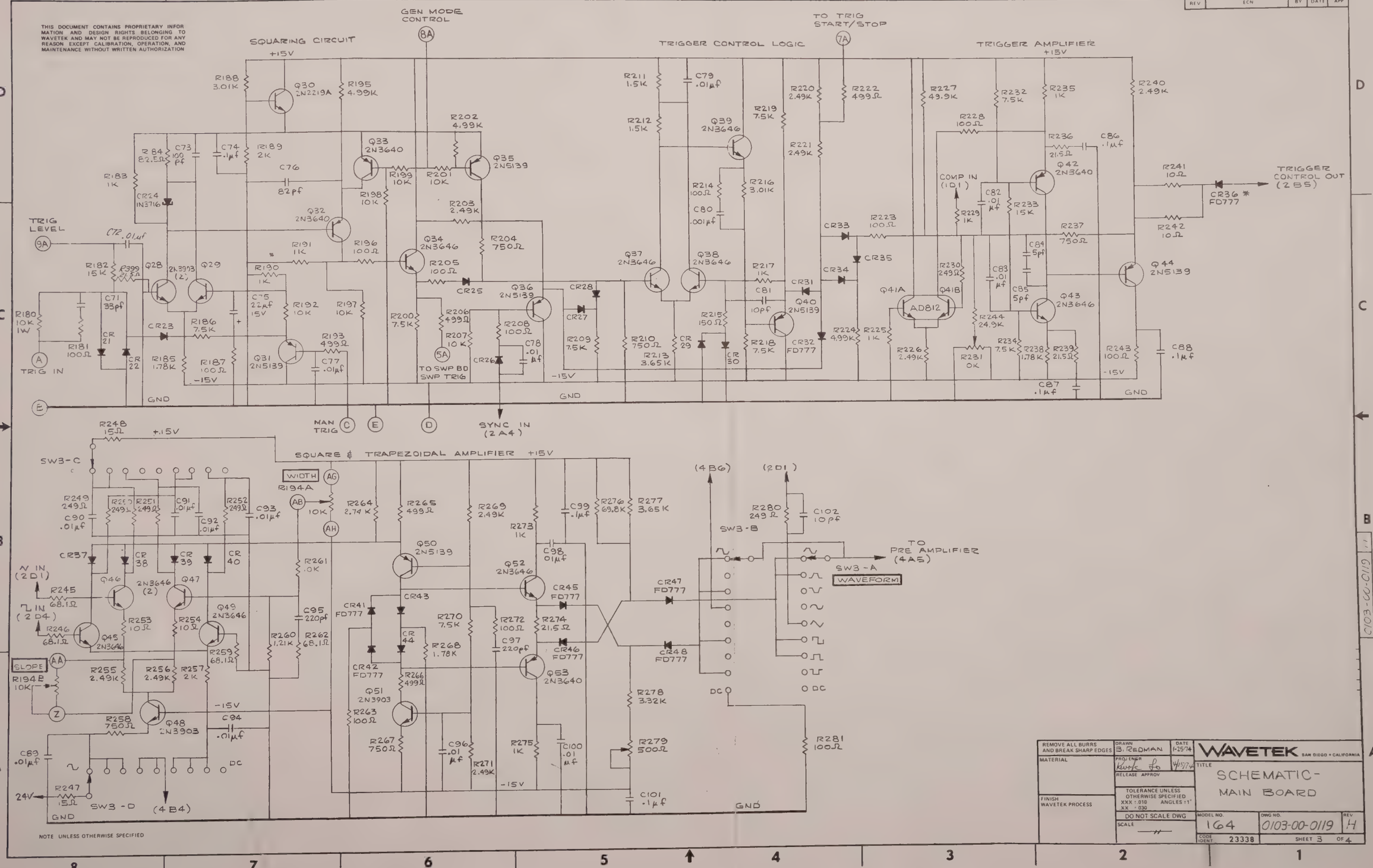
REV	ECN	BY	DATE	APP



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 1-25-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE SCHEMATIC - MAIN BOARD
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 XX ±.030 ANGLES ±1°		
	DO NOT SCALE DWG		MODEL NO. 164
	SCALE		DWG NO. 0103-00-0119 REV. H
			CODE IDENT. 23338 SHEET 3 OF 4

0103-00-0119 H

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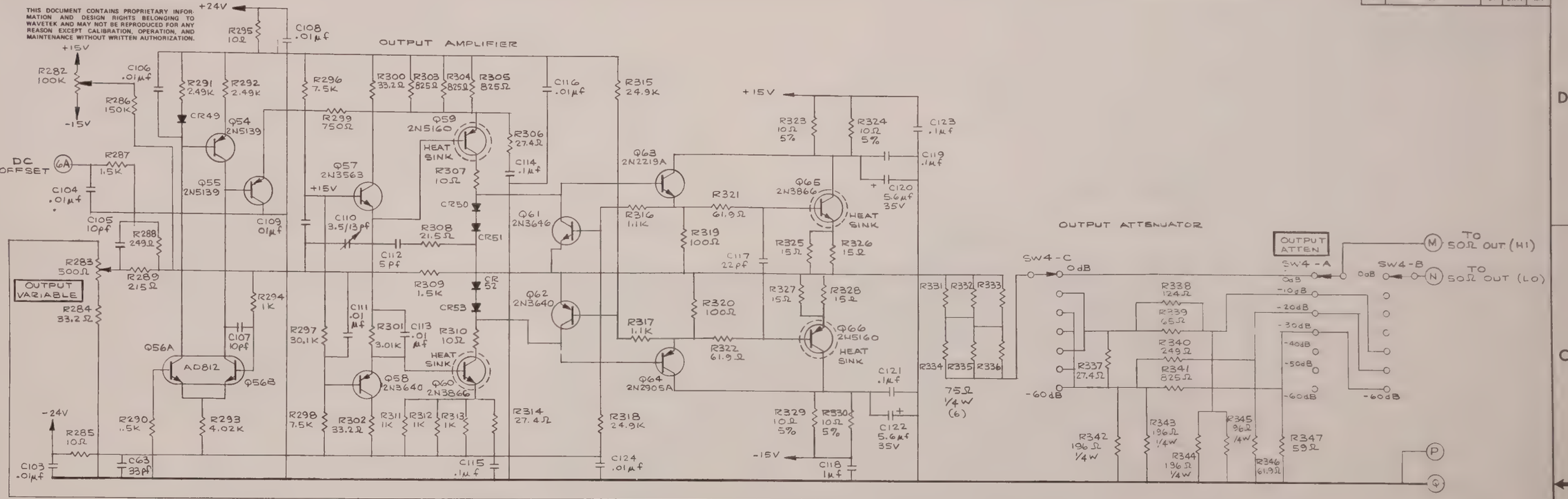

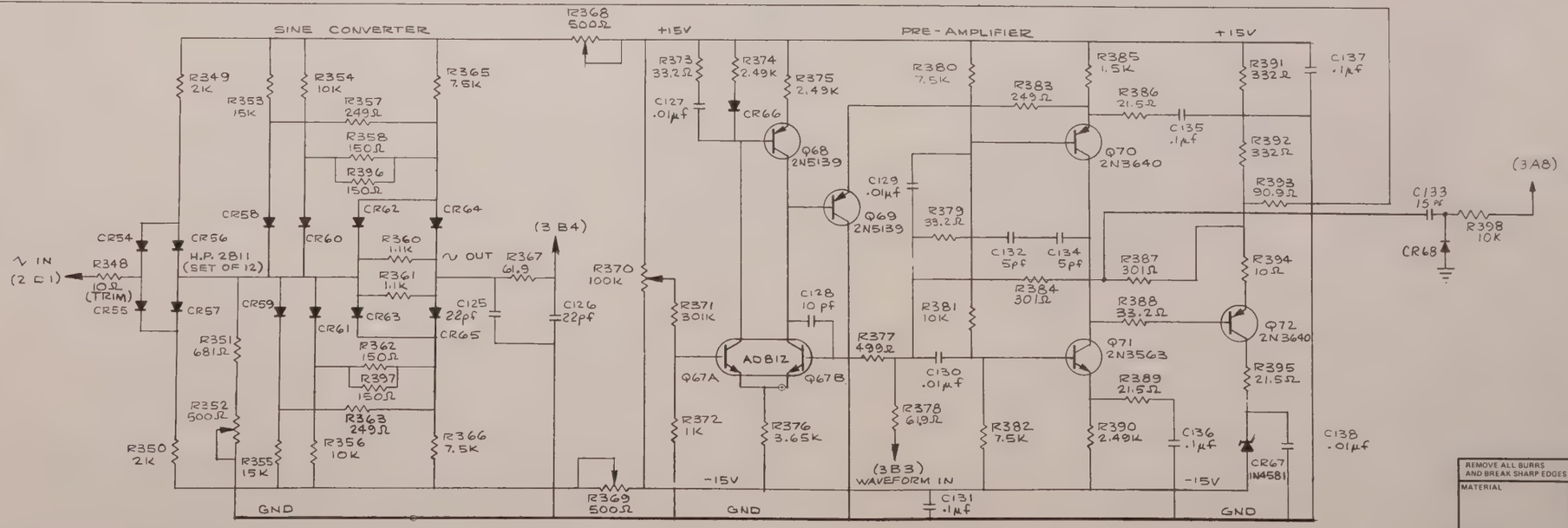

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 1-25-96	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR Kurtis Fo	4/16/96	TITLE SCHEMATIC MAIN BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030		
	DO NOT SCALE DWG	MODEL NO 164	DWG NO. 0103-00-0119 REV H
	SCALE	CODE IDENT 23338	SHEET 4 OF 4

0103-00-0119

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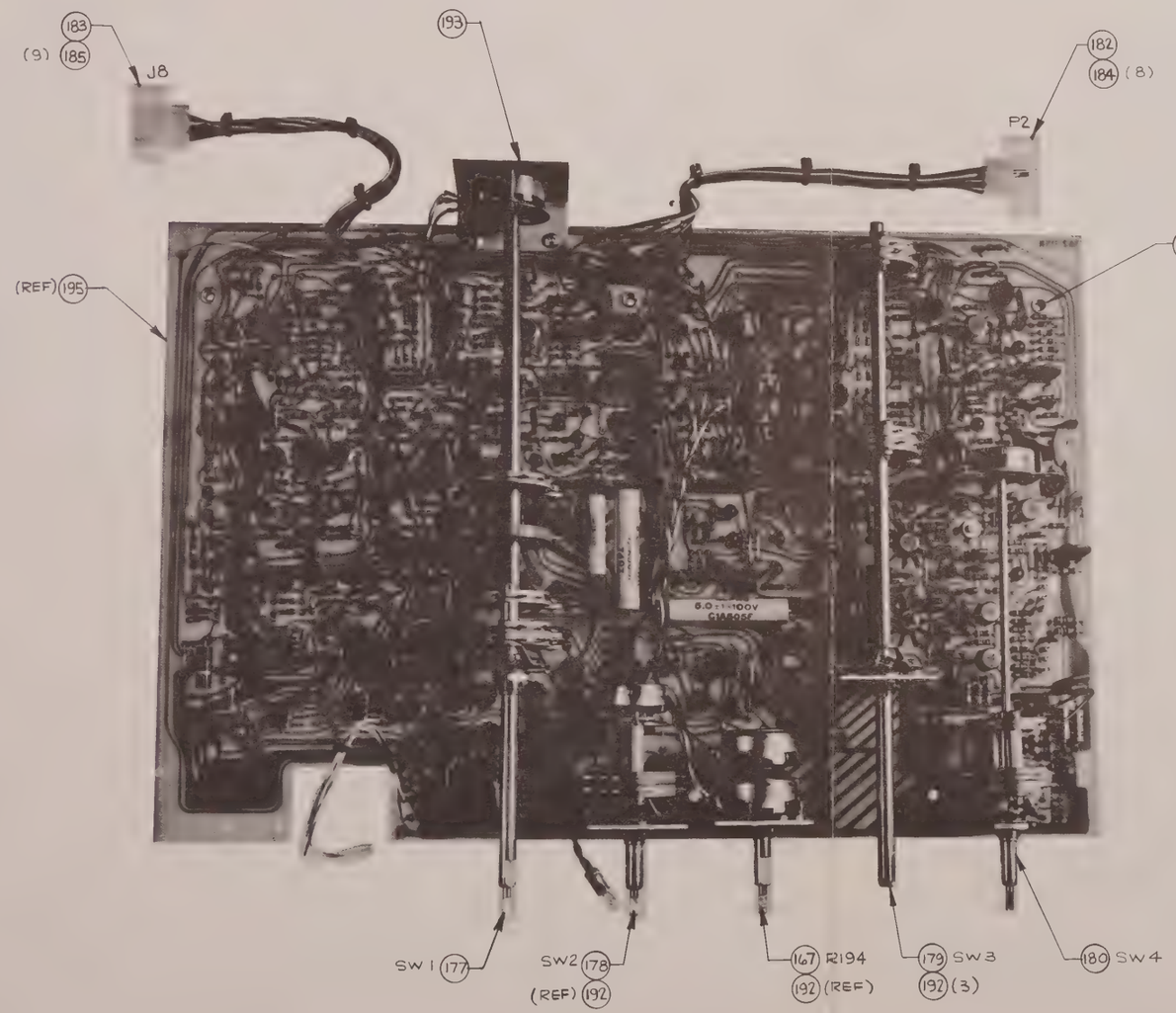
REV	ECN	BY	DATE	APP
D	ECN 904	DW	5/3/74	
E	ECN 1050	DW	7/1/74	
F	ECN 1092	RO	9/4/74	
G	ECN 1104	RO	9/23/74	
H	ECN 1129	RO	11/4/74	
J	ECN 1199	RO	2/6/75	
K	ECN 1320	RO	7-7-75	
L	ECN 1324	RO	7-9-75	
M	ECN 1507	RO	12-3-77	
N	ECN 1523	RO	2-23-78	



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REOMAN	DATE 3-19-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE ASSEMBLY, MAIN BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1 XX ± .030		
	DO NOT SCALE DWG	MODEL NO 164	DWG NO 0101-00-0119 REV N
	SCALE	CODE IDENT 23338	SHEET 1 OF 2

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REF	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	POT,DUAL,10K	162-402	AVTK	4600-21-0300	1
R323 R324 R329 R330	RES,C,1/2W,5%,10	RC20GF-100	STKPL	4700-25-0100	4
R62	RES,C,1/2W,5%,10M	RC20GF-106	STKPL	4700-25-1005	1
R63 R8	RES,C,1/2W,10%,2.2M	RC20GF-225	STKPL	4700-25-2204	2
R3 R58 R59	RES,C,1/2W,10%,6.8M	RC20GF-685	STKPL	4700-25-6804	3
R180	RES,C,1W,10%,10K	RC32GF-103	STKPL	4700-35-1002	1
R135 R137 R144 R145 R156 R158 R159 R160 R161 R173 R174 R181 R187 R196 R205 R208 R214 R223 R268 R283 R285 R272 R281 R319 R320 R69 R72	RES,MF,1/8W,1%,100	RN55D-1000F	TRW	4701-03-1000	27
R113 R117 R122 R129 R130 R177 R185 R190 R191 R217 R225 R229 R235 R273 R275 R294 R311 R312 R313 R372 R40 R41 R76	RES,MF,1/8W,1%,1K	RN55D-1001F	TRW	4701-03-1001	23
R119 R192 R197 R198 R199 R201 R207 R261 R354 R356 R381 R398 R64 R65	RES,MF,1/8W,1%,10K	RN55D-1002F	TRW	4701-03-1002	14
R105 R132 R147 R151 R155 R171 R172 R241 R242 R253 R254 R285 R295 R307 R310 R348 R370 R70	RES,MF,1/8W,1%,10	RN55D-10R0F	TRW	4701-03-1009	23

WAVETEK PARTS LIST	TITLE MAIN	ASSEMBLY NO. 1100-00-0119 PAGE: 5	REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R10	RES,MF,1/8W,1%,21.5K	RN55D-2152F	TRW	4701-03-2152	1
R236 R239 R274 R308 R386 R389 R395	RES,MF,1/8W,1%,21.5	RN55D-21R5F	TRW	4701-03-2159	7
R103 R120 R149 R21 R230 R249 R250 R251 R252 R280 R288 R340 R357 R363 R383 R55 R56 R71 R98	RES,MF,1/8W,1%,249	RN55D-2490F	TRW	4701-03-2490	14
R175 R203 R220 R221 R226 R240 R255 R256 R269 R271 R291 R292 R374 R375 R390 R4	RES,MF,1/8W,1%,2.49K	RN55D-2491F	TRW	4701-03-2491	16
R244 R25 R315 R318	RES,MF,1/8W,1%,24.9K	RN55D-2492F	TRW	4701-03-2492	4
R264	RES,MF,1/8W,1%,2.74K	RN55D-2741F	TRW	4701-03-2741	1
R306 R314 R337	RES,MF,1/8W,1%,27.4	RN55D-27R4F	TRW	4701-03-2749	3
R33 R34 384 R387	RES,MF,1/8W,1%,301	RN55D-3010F	TRW	4701-03-3010	4
R188 R216 R301	RES,MF,1/8W,1%,3.01K	RN55D-3011F	TRW	4701-03-3011	3
R297	RES,MF,1/8W,1%,30.1K	RN55D-3012F	TRW	4701-03-3012	1
R154 R2 R371	RES,MF,1/8W,1%,301K	RN55D-3013F	TRW	4701-03-3013	3
R100 R101 R108 R109 R139 R86 R87	RES,MF,1/8W,1%,316	RN55D-3160F	TRW	4701-03-3160	7
R391 R392	RES,MF,1/8W,1%,332	RN55D-3320F	TRW	4701-03-3320	2

WAVETEK PARTS LIST	TITLE MAIN	ASSEMBLY NO. 1100-00-0119 PAGE: 7	REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R85 R96					
R316 R317 R360 R361	RES,MF,1/8W,1%,1.1K	RN55D-1101F	TRW	4701-03-1101	4
R115 R123 R125 R260	RES,MF,1/8W,1%,1.21K	RN55D-1211F	TRW	4701-03-1211	4
R338 R53	RES,MF,1/8W,1%,124	RN55D-1240F	TRW	4701-03-1240	2
R127 R215 R358 R362 R396 R397 R93	RES,MF,1/8W,1%,150	RN55D-1500F	TRW	4701-03-1500	7
R102 R131 R211 R212 R22 R287 R290 R309 R35 R37 R385 R45 R48 R60 R91 R92 R99	RES,MF,1/8W,1%,1.5K	RN55D-1501F	TRW	4701-03-1501	17
R157 R182 R233 R353 R355 R6 R73 R75	RES,MF,1/8W,1%,15K	RN55D-1502F	TRW	4701-03-1502	8
R286	RES,MF,1/8W,1%,150K	RN55D-1503F	TRW	4701-03-1503	1
R104 R162 R247 R248 R325 R326 R327 R328 R97	RES,MF,1/8W,1%,15	RN55D-15R0F	TRW	4701-03-1509	9
R339	RES,MF,1/8W,1%,165	RN55D-1650F	TRW	4701-03-1650	1
R185 R238 R268	RES,MF,1/8W,1%,1.78K	RN55D-1781F	TRW	4701-03-1781	3
R38	RES,MF,1/8W,1%,1.96K	RN55D-1961F	TRW	4701-03-1961	1
R189 R257 R31 R32 R349 R350 R36 R44	RES,MF,1/8W,1%,2K	RN55D-2001F	TRW	4701-03-2001	8
R289	RES,MF,1/8W,1%,215	RN55D-2150F	TRW	4701-03-2150	1

WAVETEK PARTS LIST	TITLE MAIN	ASSEMBLY NO. 1100-00-0119 PAGE: 6	REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R107 R110 R278	RES,MF,1/8W,1%,3.32K	RN55D-3321F	TRW	4701-03-3321	3
R112 R116 R118 R121 R126 R133 R141 R148 R152 R163 R164 R167 R168 R284 R300 R302 R373 R379 R388 R88 R89 R90 R94	RES,MF,1/8W,1%,332	RN55D-33R2F	TRW	4701-03-3329	25
R11 R169 R170 R213 R277 R376	RES,MF,1/8W,1%,3.65K	RN55D-3651F	TRW	4701-03-3651	6
R128 R50 R54	RES,MF,1/8W,1%,392	RN55D-3920F	TRW	4701-03-3920	3
R295	RES,MF,1/8W,1%,4.02K	RN55D-4021F	TRW	4701-03-4021	1
R114 R83	RES,MF,1/8W,1%,464	RN55D-4640F	TRW	4701-03-4640	2
R28	RES,MF,1/8W,1%,46.4K	RN55D-4642F	TRW	4701-03-4642	1
R1	RES,MF,1.8W,1%,46.4	RN55D-46R4F	TRW	4701-03-4649	1
R67	RES,MF,1/8W,1%,47.5K	RN55D-4752F	TRW	4701-03-4752	1
R176 R178 R193 R206 R222 R265 R266 R377 R57	RES,MF,1/8,1%,499	RN55D-4990F	TRW	4701-03-4990	9
R134 R14 R195 R202 R224 R26 R27 R5	RES,MF,1/8W,1%,4.99K	RN55D-4991F	TRW	4701-03-4991	8
R227 R23 R24	RES,MF,1/8W,1%,49.9K	RN55D-4992F	TRW	4701-03-4992	3
R82	RES,MF,1/8W,1%,51.1	RN55D-51R1F	TRW	4701-03-5119	1

WAVETEK PARTS LIST	TITLE MAIN	ASSEMBLY NO. 1100-00-0119 PAGE: 8	REV

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE: MAIN BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030		
	DO NOT SCALE DWG		MODEL NO 164 / DWG NO 1100-00-0119 / REV
	SCALE		CODE IDENT 23338 / SHEET 2 OF 3

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REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R347	RES,MF,1/8W,1%,59	RN55D-59R0F	TRW	4701-03-5909	1
R321 R322 R346 R367 R378	RES,MF,1/8W,1%,61.9	RN55D-61R9F	TRW	4701-03-6199	5
R351	RES,MF,1/8W,1%,681	RN55D-6810F	TRW	4701-03-6810	1
R136 R245 R246 R259 R262	RES,MF,1/8W,1%,68.1	RN55D-68R1F	TRW	4701-03-6819	5
R13	RES,MF,1/8W,1%,6.98K	RN55D-6981F	TRW	4701-03-6981	1
R276	RES,MF,1/8W,1%,69.8K	RN55D-6982F	TRW	4701-03-6982	1
R140 R204 R210 R237 R256 R267 R294 R46 R61 R95	RES,MF,1/8W,1%,750	RN55D-7500F	TRW	4701-03-7500	10
R138 R146 R150 R165 R166 R186 R200 R209 R218 R219 R232 R234 R270 R296 R298 R365 R366 R380 R382	RES,MF,1/8W,1%,7.5K	RN55D-7501F	TRW	4701-03-7501	19
R153 R303 R304 R305 R341	RES,MF,1/8W,1%,825	RN55D-8250F	TRW	4701-03-8250	5
R184	RES,MF,1/8W,1%,82.5	RN55D-82R5F	TRW	4701-03-8259	1
R143	RES,MF,1/8W,1%,909	RN55D-9090F	TRW	4701-03-9090	1
R42	RES,MF,1/8W,1%,9.09K	RN55D-9091F	TRW	4701-03-9091	1
R393 R84	RES,MF,1/8W,1%,90.9	RN55D-90K9F	TRW	4701-03-9099	2

WAVETEK PARTS LIST | TITLE MAIN | ASSEMBLY NO. 1100-00-0119 | PAGE: 9 | REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R7	RES,MF,1/4W,1%,1M	RN60D-1004F	TRW	4701-13-1004	1
R342 R343 R344 R345	RES,MF,1/4W,1%,196	RN60D-1960F	TRW	4701-13-1960	4
R179	RES,MF,1/4W,1%,49.9	RN60D-49R9F	TRW	4701-13-4999	1
R331 R332 R333 R334 R335 R336	RES,MF,1/4W,1%,75	RN60D-75R0F	TRW	4701-13-7509	6
	RES,MF,SET,MATCHED CONSIST:4799-00-0008 THRU:0011	164-501-89A	MVTK	4789-00-0036	1
R77	RES,MF,1/8W,1%,1K PART OF 4789-00-0036 QTY:01:4701-03-1001				
R78	RES,MF,1/8W,1%,10K PART OF 4789-00-0036 QTY:01:4701-03-1002				
R79	RES,MF,1/8W,1%,100K PART OF 4789-00-0036 QTY:01:4701-03-1003				
R80	RES,MF,1/4W,1%,1M PART OF 4789-00-0036 QTY:01:4701-13-1004				
R81	RES,MF,.6W,1%,10M	ML-181	CADDO	4799-00-0003	1
CR13 CR6 CR67 CR7 CR8	DIODE	1N4581	MICRO	4801-01-4581	5
CR24	DIODE	1N3716	GE	4802-01-3716	1

WAVETEK PARTS LIST | TITLE MAIN | ASSEMBLY NO. 1100-00-0119 | PAGE: 10 | REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
CR14 CR15 CR16 CR17 CR32 CR41 CR42 CR45 CR46 CR47 CR48	DIODE	FD-777	FAIR	4807-02-0777	11
CR1 CR11 CR12 CR18 CR19 CR2 CR20 CR21 CR22 CR23 CR25 CR26 CR27 CR28 CR29 CR3 CR30 CR31 CR33 CR34 CR35 CR37 CR38 CR39 CR40 CR43 CR44 CR49 CR5 CR50 CR51 CR52 CR53 CR66 CR68	DIODE	FD-6666	FAIR	4807-02-6666	35
CR10 CR9	DIODE	5082-2811	HP	4809-02-2811	2
CR36 CR8	DIODE,M/PR,FD-777 QTY:12:4807-02-0777	164-501-93	MVTK	4898-00-0004	1
CR54 CR55 CR56 CR57 CR58 CR59 CR60 CR61 CR62 CR63 CR64 CR65	DIODE,SET,5082-2811 QTY:12:4809-02-2811	142-501-56	MVTK	4898-00-0009	1
Q30 Q63	TRANS	2N2219A	FAIR	4901-02-2191	2
Q64	TRANS	2N2905A	FAIR	4901-02-9051	1
Q13 Q21 Q57 Q71	TRANS	2N3563	FAIR	4901-03-5630	4
Q14 Q15 Q18 Q32 Q33 Q42 Q53 Q58 Q62 Q70 Q72	TRANS	2N3640	FAIR	4901-03-6400	11
Q20 Q23 Q26 Q34 Q37 Q38 Q39 Q43 Q45 Q46 Q47 Q49 Q52 Q6 Q61	TRANS	2N3646	FAIR	4901-03-6460	15

WAVETEK PARTS LIST | TITLE MAIN | ASSEMBLY NO. 1100-00-0119 | PAGE: 11 | REV

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
Q60 Q65	TRANS	2N3866	MOT	4901-03-8660	2
Q28 Q29 Q48 Q51	TRANS	2N5903	FAIR	4901-05-9030	4
Q10 Q22 Q24 Q25 Q27 Q31 Q35 Q36 Q40 Q44 Q5 Q50 Q54 Q55 Q68 Q69	TRANS	2N5139	FAIR	4901-05-1390	16
Q59 Q66	TRANS	2N5160	MOT	4901-05-1600	2
Q2 Q3 Q7	TRANS	2N5462	NSC	4901-05-4620	3
Q1 Q4	TRANS	2N5485	NSC	4901-05-4850	2
Q8	TRANS	TP-308	TPS	4902-00-3080	1
Q17 Q19	TRANS,M/PR,2N3563 QTY:2:4901-03-5630	142-501-52	MVTK	4998-00-0004	1
Q11 Q12	TRANS,M/PR,2N5139 QTY:2:4901-05-1390	164-501-88	MVTK	4998-00-0005	1
Q10 Q9	TRANS,M/PR,2N5485 QTY:2:4901-05-4850	142-501-53	MVTK	4998-00-0009	1
IC1 IC10 IC2 IC3 IC4 IC5 IC6 IC7 IC8 IC9	IC	MA-741	FAIR	7000-07-4100	10
Q41 Q56 Q67	IC	AD 812	ANDEV	7000-08-1200	3
IC11	IC	CA-3049	RCA	7000-30-4900	1

WAVETEK PARTS LIST | TITLE MAIN | ASSEMBLY NO. 1100-00-0119 | PAGE: 12 | REV

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJENGR		TITLE: MAIN BOARD
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1 XX ± .030		MODEL NO 164 · DWG NO 1100-00-0119 · REV
	DO NOT SCALE DWG		CODE IDENT 23338 · SHEET 3 OF 3
	SCALE		

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	Capacitors				
2	Ceramic Disc 1000V 22pF	CRL	71590	DD-220	5
3	Ceramic Disc 1000V 33pF	CRL	71590	DD-330	1
4	Ceramic Disc 1000V 100pF	CRL	71590	DD-101	2
5	Ceramic Disc 1000V 150pF	CRL	71590	DD-151	2
6	Ceramic Disc 1000V 220pF	CRL	71590	DD-221	1
7	Ceramic Disc 50V .01	CRL	71590	CK103	8
8	Ceramic Disc 20V .1	CRL	71590	UK-20-104	11
9					
10					
11	Silver Mica 500V 1% 1000pF	Elmenco	72136	DM19-102F	1
12	Metal Polycarbon 1% 1uF	Amer.Radionics	07994	210-BIC-105F	1
13	Electrolytic 16V 100uF	Sprague	56289	16-375-100-15T	3
14					
15					
16	Diode FD777	Fairchild	33888	FD777	2
17	Diode FD6666	Fairchild	33888	FD6666	32
18	Diode Zener 1N4581	Motorola	04713	1N4581	1
19					
20					
21	Integrated Circuit uA741	Fairchild	33888	uA741	1
22	Integrated Circuit LM318H	National	27014	LM318H	3
23	Integrated Circuit CA3049	RCA	86684	CA3049	1
24	Integrated Circuit 7400	Fairchild	33888	7400	1
25	Integrated Circuit 7404	Fairchild	33888	7404	2
26	Integrated Circuit 7420	Fairchild	33888	7420	1
27	Integrated Circuit 7474	Fairchild	33888	7404	1
28	Integrated Circuit 74161	TI	01295	74161	1
29					
30					
31	Transistor 2N3565	Fairchild	33888	2N3565	1
32	Transistor 2N3640	Fairchild	33888	2N3640	5
33	Transistor 2N3646	Fairchild	33888	2N3646	9
34	Transistor 2N5139	Fairchild	33888	2N5139	4
35	Transistor TP308	Technical Products	33888	TP308	1
36					
37					
38	Resistors				
39	Metal Film 1/8W 1% 10Ω	Corning	16299	RN55D	3
40	Metal Film 1/8W 1% 61.9Ω	Corning	16299	RN55D	1
41	Metal Film 1/8W 1% 100Ω	Corning	16299	RN55D	7
42	Metal Film 1/8W 1% 200Ω	Corning	16299	RN55D	1
43	Metal Film 1/8W 1% 249Ω	Corning	16299	RN55D	1
44	Metal Film 1/8W 1% 392Ω	Corning	16299	RN55D	1
45	Metal Film 1/8W 1% 499Ω	Corning	16299	RN55D	3
46	Metal Film 1/8W 1% 619Ω	Corning	16299	RN55D	1
47	Metal Film 1/8W 1% 750Ω	Corning	16299	RN55D	3
48	Metal Film 1/8W 1K 1%	Corning	16299	RN55D	9
49	Metal Film 1/8W 1.5K 1%	Corning	16299	RN55D	1
50	Metal Film 1/8W 2K 1%	Corning	16299	RN55D	10
51	Metal Film 1/8W 2.49K 1%	Corning	16299	RN55D	8
52	Metal Film 1/8W 2.74K 1%	Corning	16299	RN55D	1
53	Metal Film 1/8W 3.65K 1%	Corning	16299	RN55D	1
54	Metal Film 1/8W 4.02K 1%	Corning	16299	RN55D	1
55	Metal Film 1/8W 1% 4.32K	Corning	16299	RN55D	1
56	Metal Film 1/8W 1% 4.75K	Corning	16299	RN55D	3
57	Metal Film 1/8W 1% 6.99K	Corning	16299	RN55D	8
58	Metal Film 1/8W 1% 7.5K	Corning	16299	RN55D	2

PARTS LIST

LINE NO	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
59	Metal Film 1/8W 1% 8.25K	Corning	16299	RN55D	1
60	Metal Film 1/8W 1% 10K	Corning	16299	RN55D	6
61	Metal Film 1/8W 1% 13K	Corning	16299	RN55D	2
62	Metal Film 1/8W 1% 15K	Corning	16299	RN55D	3
63	Metal Film 1/8W 1% 24.9K	Corning	16299	RN55D	4
64	Metal Film 1/8W 1% 49.9K	Corning	16299	RN55D	1
65	Metal Film 1/8W 1% 100K	Corning	16299	RN55D	1
66					
67					
68	Metal Film 1/4W 1% 1M	Corning	16299	RN60D	1
69	Metal Film .6W 1% 10M	Caddock	19647	ML181	1
70					
71	Matched Set 30.1K (-90)	Corning	16299	RN55	1set
72					
73	Potentiometer 1K	Beckman	80740	91AR1K	1
74	Potentiometer 5K	Beckman	80740	91AR5K	2
75	Potentiometer 100K	Beckman	80740	91AR100K	1
76					
77	Standoff	Lyntron	05791	6310-4-2C	2
78	Connector Plug	Molex		03-06-2091	1
79	Pin, Male	Molex		02-06-1103	9
80					
81					
82	Switch Assy	Wavetek	23338	D164-005	1
83	Switch Assy	Wavetek	23338	D164-006	1
84	Switch Assy	Wavetek	23338	D164-007	1
85	Switch Assy	Wavetek	23338	D164-008	1
86	Switch Assy	Wavetek	23338	D164-009	1
87	Bracket	Wavetek	23338	B133-305	1
88					
89					
90	Circuit Board	Wavetek	23338	164-111-C	1
91					
92	Schematic	Wavetek	23338	D164-211	REF
93					
94					
95					
96					
97					
98					
99					
100					
101					
102					
103					
104					
105					
106					
107					
108					
109					
110					
111					
112					
113					
114					
115					
116					

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
C1	8	CR20	17	R1	61
C2	8	CR21	17	R2	50
C3	5	CR22	17	R3	71
C4	8	CR23	17	R4	71
C5	8	CR24	17	R5	71
C6	7	CR25	17	R6	71
C7	3	CR26	17	R7	71
C8	7	CR27	17	R8	41
C9	2	CR28	16	R9	71
C10	4	CR29	16	R10	71
C11	2	CR30	17	R11	60
C12	2	CR31	17	R12	61
C13	13	CR32	17	R13	45
C14	8	CR33	17	R14	51
C15	8	CR34	17	R15	41
		CR35	17	R16	39
C17	8			R17	39
C18	13	IC1	21	R18	63
C19	8	IC2	22	R19	74
C20	13	IC3	22	R20	63
C21	7	IC4	28	R21	52
C22	5	IC5	27	R22	51
C23	7	IC6	26	R23	63
C24	13	IC7	24	R24	74
C25	12	IC8	25	R25	63
C26	7	IC9	25	R26	57
C27	4	IC10	22	R27	57
C28	8	IC11	23	R28	46
C29	8			R29	83
C30	2	Q1	34	R30	51
C31	2	Q2	33	R31	50
C32	7	Q3	33	R32	48
C33	6	Q4	33	R33	48
C34	7	Q5	33	R34	50
C35	7	Q6	33	R35	48
C36	8	Q7	31	R36	50
CR1	17	Q8	33	R37	48
CR2	17	Q9	33	R38	57
CR3	17	Q10	32	R39	51
CR4	17	Q11	32	R40	48
CR5	17	Q12	33	R41	57
CR6	17	Q13	32	R42	59
CR7	17	Q14	35	R43	57
CR8	17	Q15	34	R44	48
CR9	17	Q16	32	R45	48
CR10	17	Q17	32	R46	84
CR11	17	Q18	34	R47	44
CR12	18	Q19	34	R48	57
CR13	17	Q20	33	R49	40
CR14	17			R50	55
CR15	17			R51	65
CR16	17				
CR17	17				
CR18	17				
CR19	17				

LINE ITEM REFERENCE LIST

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
R52	68	R82	60		
R53	69	R83	41		
R54	54	R84	49		
R55	51	R85	50		
R56	39	R86	47		
R57	62	R87	57		
R58	60	R88	47		
R59	42	R89	50		
R60	62	R90	60		
R61	62	R91	60		
R62	48	R92	47		
R63	51	R93	58		
R64	56	R94	45		
R65	56	R95	53		
R66	50	R96	60		
R67	56	R97	43		
R68	51	R98	41		
R69	51	R99	41		
R70	58	R100	82		
R71	73	R101	85		
R72	75	R102	86		
R73	64				
R74	57	SW5	82		
R75	41	SW6	85		
R76	45	SW7	86		
R77	50	SW8	83		
R78	50	SW9	84		
R79	48				
R80	50				
R81	41				

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B REDMAN	DATE 2 28 74	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE ASSEMBLY, SWEEP BOARD
	RELEASE APPROV	4/8/74	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1 XX .030		
	DO NOT SCALE DWG	MODEL NO 164	DWG NO B164-011 REV B
	SCALE NONE	CODE IDENT 23338	SHEET 2 OF 2

B164-011 B

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REV	ECN	BY	DATE	APP

10-STEP D/A CONVERTER

+15V
R3 30.1K *
R4 30.1K *
R5 30.1K *
R6 30.1K *
R7 30.1K *
R9 30.1K *
R10 30.1K *
R1 13K
CR1 CR2 CR3 CR4 CR5 CR6 CR7 CR8 CR9 CR10 CR11 CR35
CR34
IC1 μA741
Q1 2N5139
R8 100Ω
R12 13K
R2 2K
C1 .1μf
C2 .1μf
C3 150pf
R11 10K
-15V
GND

SWEEP DOWN AMPLIFIER

+15V
R17 10Ω
C7 33pf
R21 2.74K
SWEEP/STEP TIME
10 μs 100μs 1ms 10ms 100ms 1s 10s 100s OFF
SW9-A
C4 .1μf
C6 .01μf
R15 100Ω
IC2 LM318
R14 2.49K
C5 .1μf
R16 10Ω
R18 24.9K
R20 24.9K
R19 5K
RAMP IN (2C3)
R13 499Ω
RAMP UP
STEP DOWN
-15V SW8-B
GND

SWEEP UP AMPLIFIER

RAMP UP
R26 4.99K
R27 4.99K
STEP DOWN SW8-D
R30 2.49K
R29 10K SWEEP WIDTH
SW5-D
CONT
SINGLE STEP
SWEEP OUT TO MAIN BD (A)
C8 .01μf
IC3 LM318
R22 2.49K
R23 24.9K
R25 24.9K
R28 619Ω
R24 5K
TO SWP OUT (B)
GND (C)

+5V
R33 1K
C9 22pf
IC9A
IC5B
IC7B
IC4 74161
IC8C Q1
IC8B Q2
IC8A Q3
IC8E Q4
IC6B
IC9C
C10 100pf
IC5A
IC7C
C11 22pf
R34 2K
R35 1K
OCL (2B4)
Q4 2N3646
Q3 2N3646
R32 1K
Q2 2N3646
R31 2K
GCL (2B5)
GND

+5V
R37 1K
C12 22pf
LOGIC TRIG (2B4)
R36 2K
Q5 2N3646
CONT
SINGLE STEP SW5-C
GND

+5V
R39 2.49K
R40 1K
Q6 2N3646
R38 4.99K
RAMP UP
STEP DOWN SW8-C
IC9F
IC7D
IC9D
IC7A
IC6A
IC9E
IC8D
Vcc
R41 4.99K
GND

+5V (4) → C13 100μf 16V, C14 .1μf, C15 .1μf, C36 .1μf → +5V PIN 14 IC4-IC9, GND PIN 7 IC4-IC9

+15V (2) → C19 .1μf, C20 100μf 16V → +15V, -15V
-15V (3) → C17 .1μf, C18 100μf 16V → COM
COM (1) → COM

3. * RESISTOR MATCHED SET (± .1%).
2. RESISTORS ARE 1/8 W, 1%, METAL FILM.
1. DIODES ARE FD6666.

NOTE UNLESS OTHERWISE SPECIFIED

LAST REFERENCE DESIGNATIONS USED

CAPACITORS	C35
DIODES	CR35
INTEGRATED CIRCUITS	IC11
TRANSISTORS	Q20
RESISTORS	R102

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 1-10-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJENG		TITLE SCHEMATIC SWEEP BOARD
	RELEASE APPROV	4/4/74	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030		
	DO NOT SCALE DWG		MODEL NO. 164 DWG NO. D164-211 REV A
	SCALE		CODE IDENT 23338 SHEET 1 OF 2

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REV	ECN	BY	DATE	APP

RAMP GENERATOR AMPLIFIER

+15V

R45 1K
R46 10K
R47 392Ω
R48 4.99K
CR12 IN4581
SWEEP/STEP TIME VARIABLE
CR13
SW9-C
10µS
R50 4.32K
R51 100K
R52 1M 1%
R53 10M 1%
OFF
C21 .01 µf
R42 8.25K
Q7 2N3565
R43 4.99K
R44 1K
GND

R57 15K
R59 200Ω
Q12 2N3646
Q13 2N3640
Q10 2N3640
R54 4.02K
R56 10Ω
R58 10K
Q8 2N3646
Q9 2N3646
Q11 2N3640
CR14
C23 .01 µf
R49 61.9Ω
R55 2.49K
C22 150pf
-15V

SW9-B
10µS
OFF
C24 1000pf 1%
C25 1 µf 1%

Q14A Q14B
TP308
R62 1K
R60 15K
R61 15K

IC10 LM318
C26 .01 µf
C27 100 pf
R63 2.49K

R64 4.75K
R65 4.75K
R67 4.75K
C28 .1 µf
CR15
CR16
CR17
CR18
CR19
CR20
CR21
CR22
R66 2K
RAMP OUT (1C6)
C29 .1 µf
GND
-15V

+15V RAMP GEN HYSTERESIS SWITCH

R74 4.99K
R72 100K
R73 49.9K
C31 22pf
R68 2.49K
R69 2.49K
C30 22pf
CR23
CR24
CR25
R70 7.5K
R71 1K
R75 100Ω
Q15 2N5139
R76 499Ω
R77 2K
C32 .01 µf
R81 100Ω
R82 10K
R83 100Ω
R84 1.5K
R85 2K
R86 750Ω
Q18 2N5139
GND
-15V

R78 2K
R79 1K
R80 2K
Q16 2N3640
Q17 2N3640
CR26
CR27
IC11 CA3049

RAMP LOGIC CONTROL

R87 4.99K
CLOCK (1B8)
R91 10K
OCL (1B5)
R92 750Ω
CR28 FD777
CR30
R88 750Ω
Q19 2N5139
R93 7.5K
CR31
C33 220pf
CR29 FD777
CR32
CR33
R89 2K
R90 10K
R94 499Ω
R95 3.65K
GND

+15V
R98 100Ω
C34 .01 µf
Q20 2N3646
R97 249Ω
R96 10K
LOGIC TRIG (1B5)
R99 100Ω
C35 .01 µf
SWEEP MODE
RAMP UP
RAMP DOWN
STEP UP
STEP DOWN
SW8-A
GEN MODE
SW5-A
CONT
TRIG
GATED
SWP BURST
CONT SWP
TRIG SWP
SWP HOLD
SINGLE STEP
GND
-15V

R100 10K
TRIG LEVEL
DC OFFSET
SW7-B
SW7-A
R102 10K
TRIG BASE LINE
GEN MODE
VAR
R101 10K
SW6-A
TRIG START/STOP
SINGLE STEP
SW5-B
GND

5) RAMP TRIG
3) TRIG LEVEL
6) DC OFFSET
7) TRIG BASE LINE
3) GEN MODE

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 1-10-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR Kirk Lo	4/15/74	TITLE SCHEMATIC SWEEP BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1° XX ± .030		MODEL NO 164
	DO NOT SCALE DWG		DWG NO. D164-211 REV A
	SCALE		CODE IDENT 23338 SHEET 2 OF 2

D164-211 A

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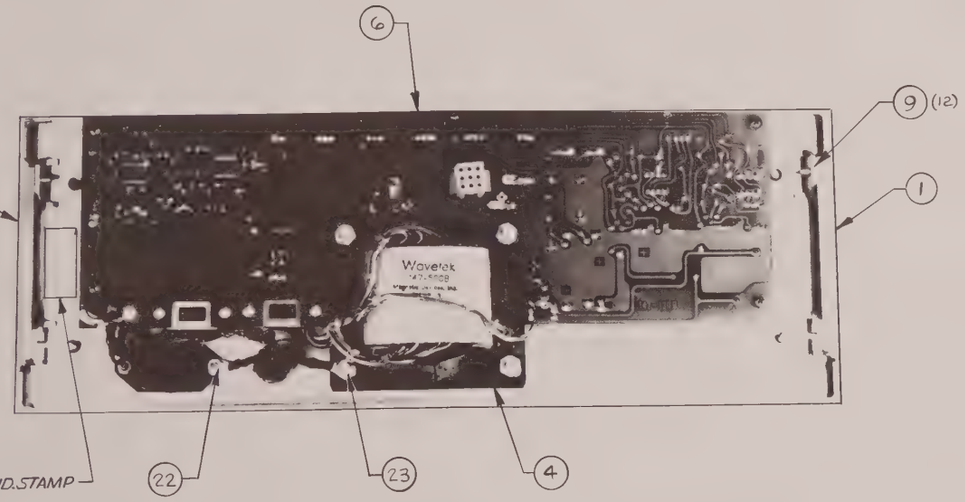
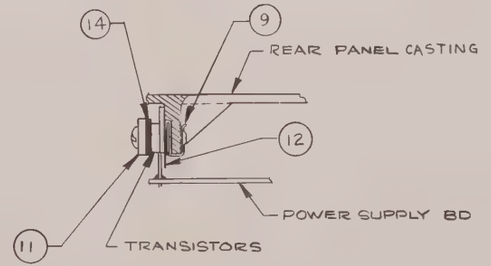
REV	ECN	BY	DATE	APP
B	ECN 1052	RJ	10/1/4	
C	ECN 1324	RJ	7/10/5	
D	DDC #1464	DC	9/1/6	
E	ECN 1525	RO	3-1-77	





TRANSISTOR CLAMP DETAILS

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	REAR PANEL CASTING	WAVETEK	23338	D147-359	1
2					
3					
4	TRANSFORMER			A147-500	1
5	NAME PLATE			B147-370	1
6	POWER SUPPLY BD			D162-030	1
7					
8	ZIP TWIST NUT	PAL		BD-125009	4
9	U-NUT	TINNERMAN		C18050-632-4	12
10					
11	CLAMPING BAR	WAVETEK		A147-379	1
12	INSULATOR			B147-367	1
13					
14	COMPRESSION STRIP	WAVETEK		B162-312	1
15					
16					
17	FUSE HOLDER	LITTELFUSE	75915	345001	1
18	FUSE 1/2 AMP (115V)			313.500	1
19	FUSE 1/4 AMP (230V)			313.250	1
20	POWER CONNECTOR	SWITCHCRAFT	82389	EAC-301	1
21					
22	SOLDER LUG	H.H. SMITH	83330	1414-4	1
23	SOLDER LUG			1414-8	1

1. FOR CHASSIS WIRING SEE CHASSIS SCHEMATIC D162-200.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B.REDMAN DATE 3-1-74
PROJENGR Kirk Lo 4/1/76
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 ANGLES ±1 XX .030
DO NOT SCALE DWG
SCALE NONE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE ASSEMBLY, REAR PANEL

MODEL NO 162 | DWG NO D162-001 | REV E

CODE IDENT 23338 | SHEET 1 OF 1

D162-001 D

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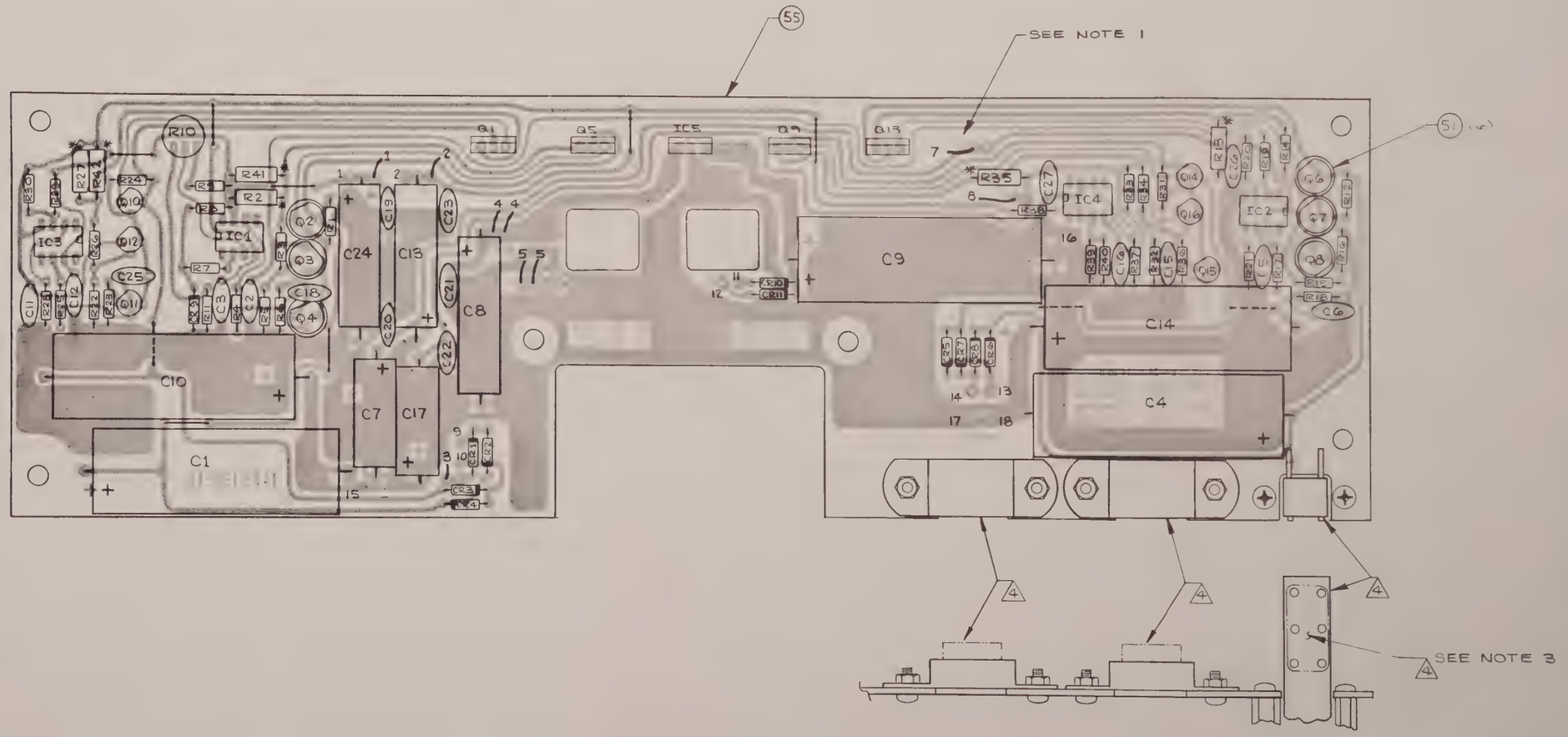
REV	ECN	BY	DATE	APP
E	ECN 1103	RO	9/24/74	
F	ECN 1116	BA	10-15-74	
G	ECN 1212	BA	2-18-75	
H	ECN 1324	RO	7-9-75	



4 SHOWN FOR REFRENCE ONLY. SEE SHEET 2 FOR DETAILS.

3. APPLY SILICONE RUBBER (ITEM 59) AS REQUIRED TO THIS AREA ENCAPSULATING PROTRUDING SWITCH CONTACT PINS (THIS SIDE ONLY)
2. * INDICATES RESISTORS MOUNTED OFF BOARD.
1. NUMBERS INDICATE CHASSIS WIRING SEE CHASSIS SCHEMATIC.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3-14-74
MATERIAL	ENG APPR. Kwok Lo	7/1/74
	MFG APPR. (T.O.)	3/1/75
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030	
	DO NOT SCALE DWG	
	SCALE 2/1	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: ASSEMBLY, POWER SUPPLY BD

MODEL NO	DWG NO	REV
147	D147-030	H

CODE IDENT 23338 SHEET 1 OF 3

D147-030 E

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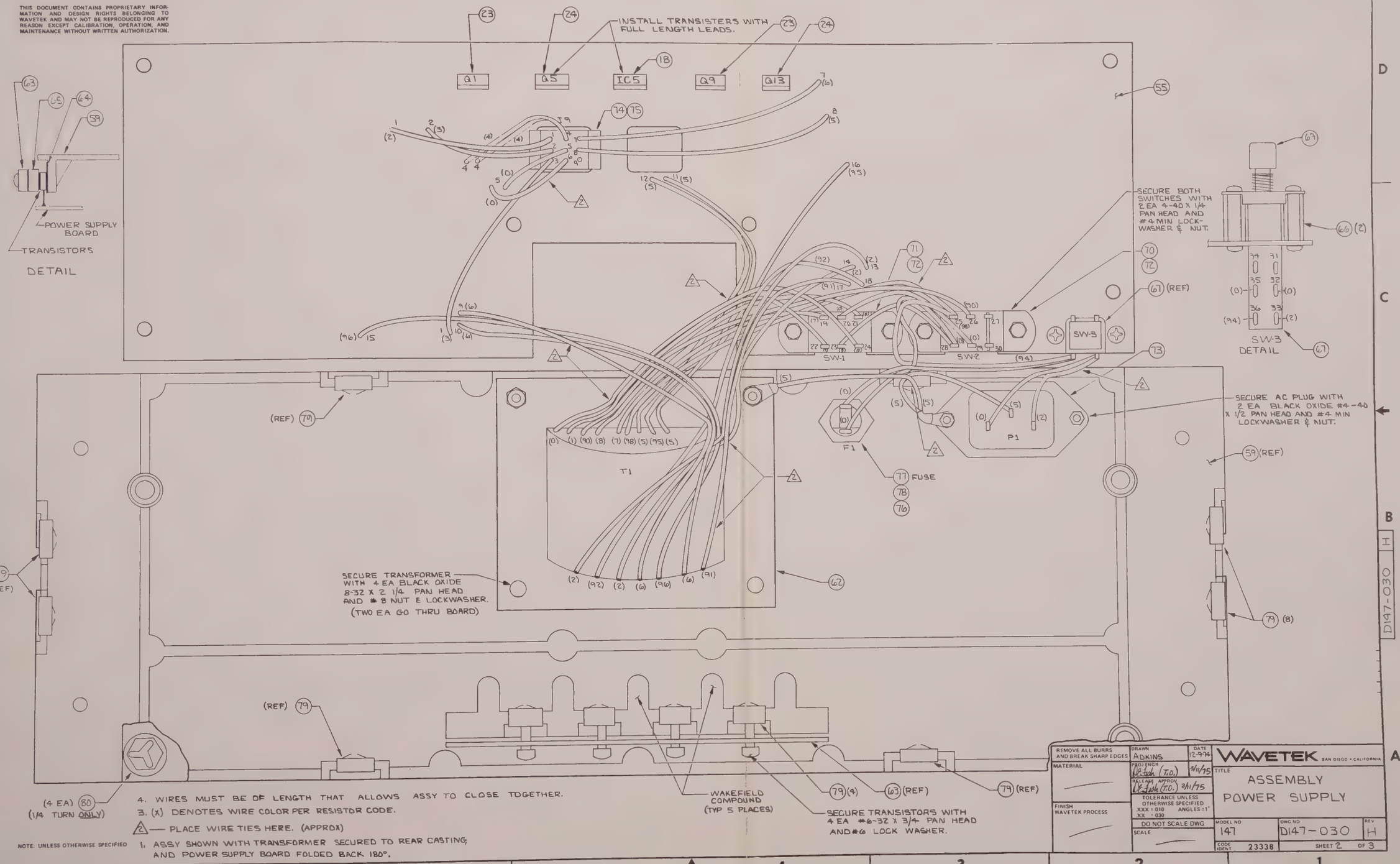
REV	ECN	BY	DATE	APP


INSTALL TRANSISTERS WITH FULL LENGTH LEADS.
Q1
Q5
IC5
Q9
Q13
POWER SUPPLY BOARD
TRANSISTORS
DETAIL
SECURE BOTH SWITCHES WITH 2 EA 4-40 X 1/4 PAN HEAD AND #4 MIN LOCK-WASHER & NUT.
SW-1
SW-2
SW-3
SW-3 DETAIL
SECURE AC PLUG WITH 2 EA BLACK OXIDE #4-40 X 1/2 PAN HEAD AND #4 MIN LOCKWASHER & NUT.
T1
F1
FUSE
P1
SECURE TRANSFORMER WITH 4 EA BLACK OXIDE 8-32 X 2 1/4 PAN HEAD AND #8 NUT & LOCKWASHER. (TWO EA GO THRU BOARD)
WAKEFIELD COMPOUND (TYP 5 PLACES)
SECURE TRANSISTORS WITH 4 EA #6-32 X 3/4 PAN HEAD AND #6 LOCK WASHER.
(4 EA) (80) (1/4 TURN ONLY)

4. WIRES MUST BE OF LENGTH THAT ALLOWS ASSY TO CLOSE TOGETHER.
3. (X) DENOTES WIRE COLOR PER RESISTOR CODE.
2. — PLACE WIRE TIES HERE. (APPROX)
1. ASSY SHOWN WITH TRANSFORMER SECURED TO REAR CASTING; AND POWER SUPPLY BOARD FOLDED BACK 180°.

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKINS	DATE 12-9-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ MGR		TITLE ASSEMBLY POWER SUPPLY
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1° XX ±.030		
	DO NOT SCALE DWG	MODEL NO 147	DWG NO D147-030 REV H
	SCALE	CODE IDENT 23338	SHEET 2 OF 3

D147-030 H

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REV	ECN	BY	DATE	APP

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
1	Capacitors				
2	Ceramic Disc 1000V 33pF	CRL	71590	DD330	2
3	Ceramic Disc 50V .01μF	CRL	71590	CK103	8
4	Ceramic Disc 20V .1μF	CRL	71590	UK20-104	7
5					
6	Electrolytic 50V 50μF	Sprague	56289	500D506G050DD7	2
7	Electrolytic 16V 250μF	Sprague	56289	22-437-250-15T	3
8	Electrolytic 50V 500μF	Sprague	56289	39D507G050GL4	2
9	Electrolytic 35V 1000μF	Sprague	56289	36-750-1000-35T	2
10	Electrolytic 15V 1900μF	Sprague	56289	39D198G015GL4	1
11					
12					
13	Diode Rectifier	Semtech	14099	SCE1	10
14	Diode Zener	Wavetek	23338	A130-506	1
15					
16					
17	Integrated Circuit	Fairchild	33888	μA741TC	4
18	Integrated Circuit 7805	Fairchild	33888	MC7805	1
19					
20					
21	Transistor 2N3642	Fairchild	33888	2N3642	6
22	Transistor 2N4248	Fairchild	33888	2N4248	6
23	Transistor TIP-29	Tex Instr	01295	TIP-29	2
24	Transistor TIP-30	Tex Instr	01295	TIP-30	2
25					
26					
27	Resistors				
28	Metal Film 1/8W 1% 392Ω	Corning	16299	RN55D	2
29	Metal Film 1/8W 1% 464Ω	Corning	16299	RN55D	2
30	Metal Film 1/8W 1% 681Ω	Corning	16299	RN55D	2
31	Metal Film 1/8W 1% 2.21K	Corning	16299	RN55D	4
32	Metal Film 1/8W 1% 2.74K	Corning	16299	RN55D	2
33	Metal Film 1/8W 1% 2.87K	Corning	16299	RN55D	1
34	Metal Film 1/8W 1% 3.92K	Corning	16299	RN55D	1
35	Metal Film 1/8W 1% 4.75K	Corning	16299	RN55D	7
36	Metal Film 1/8W 1% 5.76K	Corning	16299	RN55D	2
37	Metal Film 1/8W 1% 6.19K	Corning	16299	RN55D	1
38	Metal Film 1/8W 1% 8.25K	Corning	16299	RN55D	1
39	Metal Film 1/8W 1% 9.09K	Corning	16299	RN55D	2
40	Metal Film 1/8W 1% 9.53K	Corning	16299	RN55D	2
41	Metal Film 1/8W 1% 18.2K	Corning	16299	RN55D	2
42	Metal Film 1/8W 1% 38.3K	Corning	16299	RN55D	2
43					
44					
45	Carbon 1/2W 5% 3.9Ω	Stackpole	29604	RC20GF	6
46					
47	Matched Set 10K (-64)	Corning	16299	RN55D	1set
48					
49	Potentiometer 1K	Beckman	80740	91AR1K	1
50					
51	Transipad	Milton Ross	07047	10123N	6
52					
53	Silicone Rubber	Dow Corning	71894	3140	AR
54					
55	Circuit Board	Wavetek	23338	147-130C	1
56					
57	Schematic	Wavetek	23338	D147-230	REF
58					

PARTS LIST

LINE NO.	DESCRIPTION	MFGR	FSCM	MFGR P/N	QTY
59	CASTING REAR	WAVETEK	23338	D147-359	1
60	NAME TAG (SERIAL NO.)			147-370	1
61					
62	TRANSFORMER			C147-500	1
63	BAR CLAMPING			B147-379	1
64	INSULATOR STRIP			B147-367	1
65	COMPRESSION STRIP			B162-312	1
66	STAND-OFF			013-003-1	2
67	SWITCH POWER	WAVETEK	23338	157-422	1
68					
69	BUTTON (BLK)	CRL	71590	J52315 (BLK)	1
70	SWITCH (115-230)	SWITCHCRAFT	82389	46256LF	1
71	SWITCH (HI-LO)			SW422-FT-HK	1
72	SOLDER GUARD			46256LF-SG	2
73	RECEPTACLE AC POWER CORD	SWITCHCRAFT	82389	EAC-301	1
74	CONNECTOR (9 PIN)	MOLEX	27264	03-06-1091	1
75	PIN (FEMALE)	MOLEX	27264	02-06-1103	9
76	FUSE HOLDER	LITTLEFUSE	75915	345001	1
77	FUSE 115 VAC 1/2A (115V)			313-500	1
78	FUSE 1/4A (250V)	LITTLEFUSE	75915	MDL 1/4	1
79	U-NUT	TINNERMAN		C1805-632-4	12
80	ZIP TWIST NUT	PAL		BD125009	4
81					
82	SOLDER LUG	H.H SMITH	83330	1414-4	1
83	SOLDER LUG			1414-8	1
84					
85					
86					

REF DES	P/L LINE	REF DES	P/L LINE	REF DES	P/L LINE
C1	9	Q1	23	R40	36
C2	4	Q2	21	R41	45
C3	4	Q3	21	R42	45
C4	8	Q4	21		
C5	3	Q5	23		
C6	3	Q6	21		
C7	6	Q7	21		
C8	7	Q8	21		
C9	10	Q9	24		
C10	9	Q10	22		
C11	4	Q11	22		
C12	4	Q12	22		
C13	7	Q13	24		
C14	8	Q14	22		
C15	3	Q15	22		
C16	3	Q16	22		
C17	6				
C18	2	R1	35		
C19	4	R2	45		
C20	3	R3	28		
C21	4	R4	31		
C22	3	R5	39		
C23	4	R6	29		
C24	7	R7	34		
C25	2	R8	33		
C26	3	R9	38		
C27	3	R10	49		
		R11	37		
CR1	13	R12	35		
CR2	13	R13	45		
CR3	13	R14	30		
CR4	13	R15	42		
CR5	13	R16	32		
CR6	13	R17	31		
CR7	13	R18	41		
CR8	13	R19	35		
CR9	14	R20	36		
CR10	13	R21	40		
CR11	13	R22	39		
		R23	29		
IC1	17	R24	35		
IC2	17	R25	31		
IC3	17	R26	28		
IC4	17	R27	45		
IC5	18	R28	35		
		R29	47		
		R30	47		
		R31	35		
		R32	32		
		R33	42		
		R34	30		
		R35	45		
		R36	41		
		R37	31		
		R38	35		
		R39	40		

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN: F. FIFER	DATE: 7-9-75	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL: —	PROJ ENGR: T. O.	3-11-75	TITLE: ASSEMBLY POWER SUPPLY
FINISH: WAVETEK PROCESS —	RELEASE APPROV: W. L.	3-11-75	ALSO USED ON 167
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1° XX ±.030		MODEL NO. 147 / DWG NO. B147-030 / REV H
	DO NOT SCALE DWG		CODE IDENT 23338 / SHEET 3 OF 3
	SCALE —		

B147-030 H

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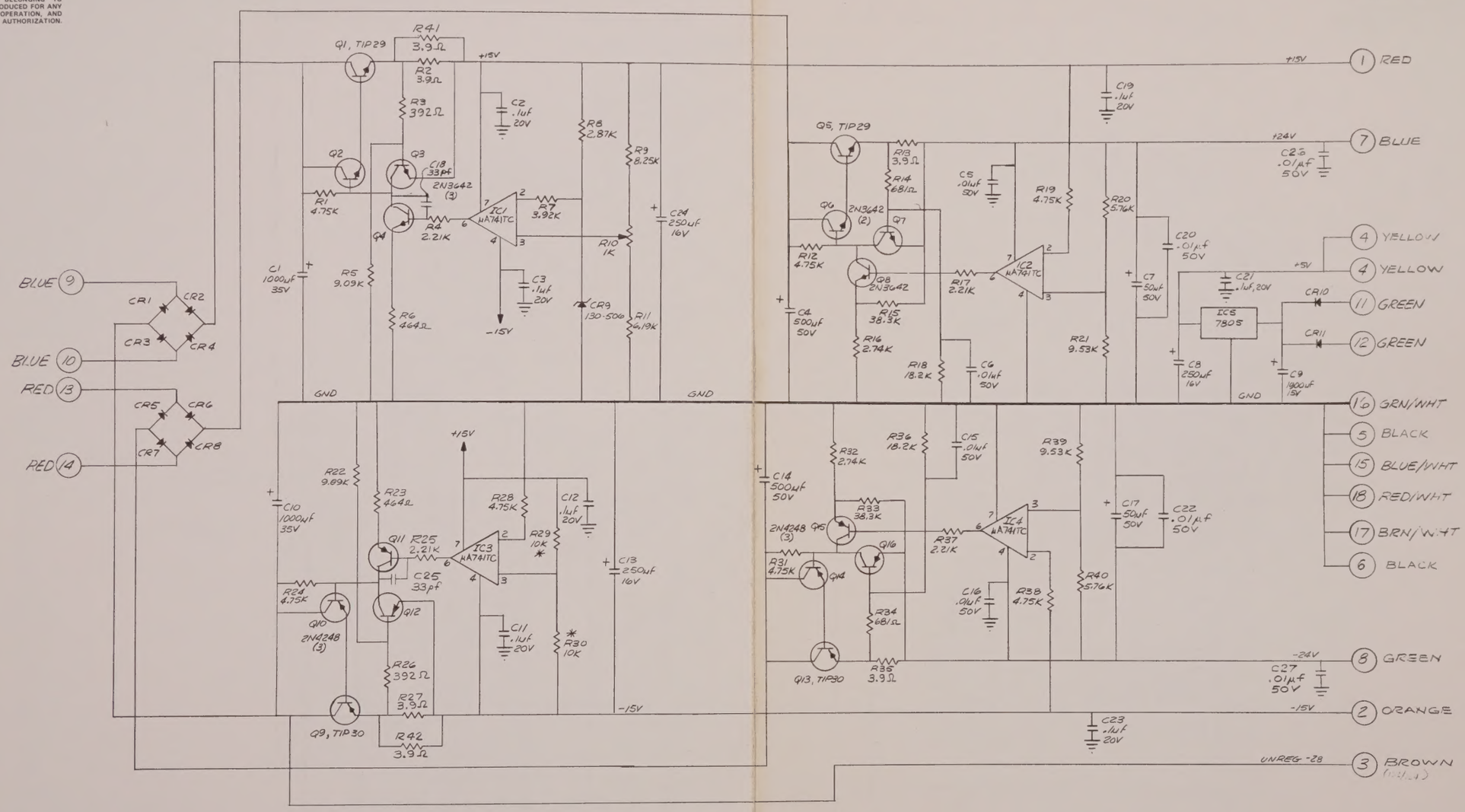
REV	ECN	BY	DATE	APP
B		BA	12-13-74	



LAST DESIGNATORS USED	NOT USED
CAPACITOR C27	
DIODE CR11	
INTEGRATED CIRCUIT IC5	
TRANSISTOR Q16	
RESISTOR R42	

1) COLORED CALLOUTS INDICATE TRANSFORMER LEADS
3) SEE CHASSIS SHEMATIC D147-200 FOR INTERWIRING
2) DIODES ARE SCE-1
1) * INDICATES MATCHED PAIR (R29, R30)

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN Bochicchio	DATE 9/1972	WAVETEK SAN DIEGO + CALIFORNIA
MATERIAL	PROJ ENGR Frank E. Fox		TITLE SCHEMATIC POWER SUPPLY BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV [illegible] (Tho.)	3/11/75	
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1° XX ±.030		MODEL NO. 147
	DO NOT SCALE DWG		DWG NO. D147-230 REV B
	SCALE		CODE IDENT 23338 SHEET 1 OF 1

D147-230 A

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